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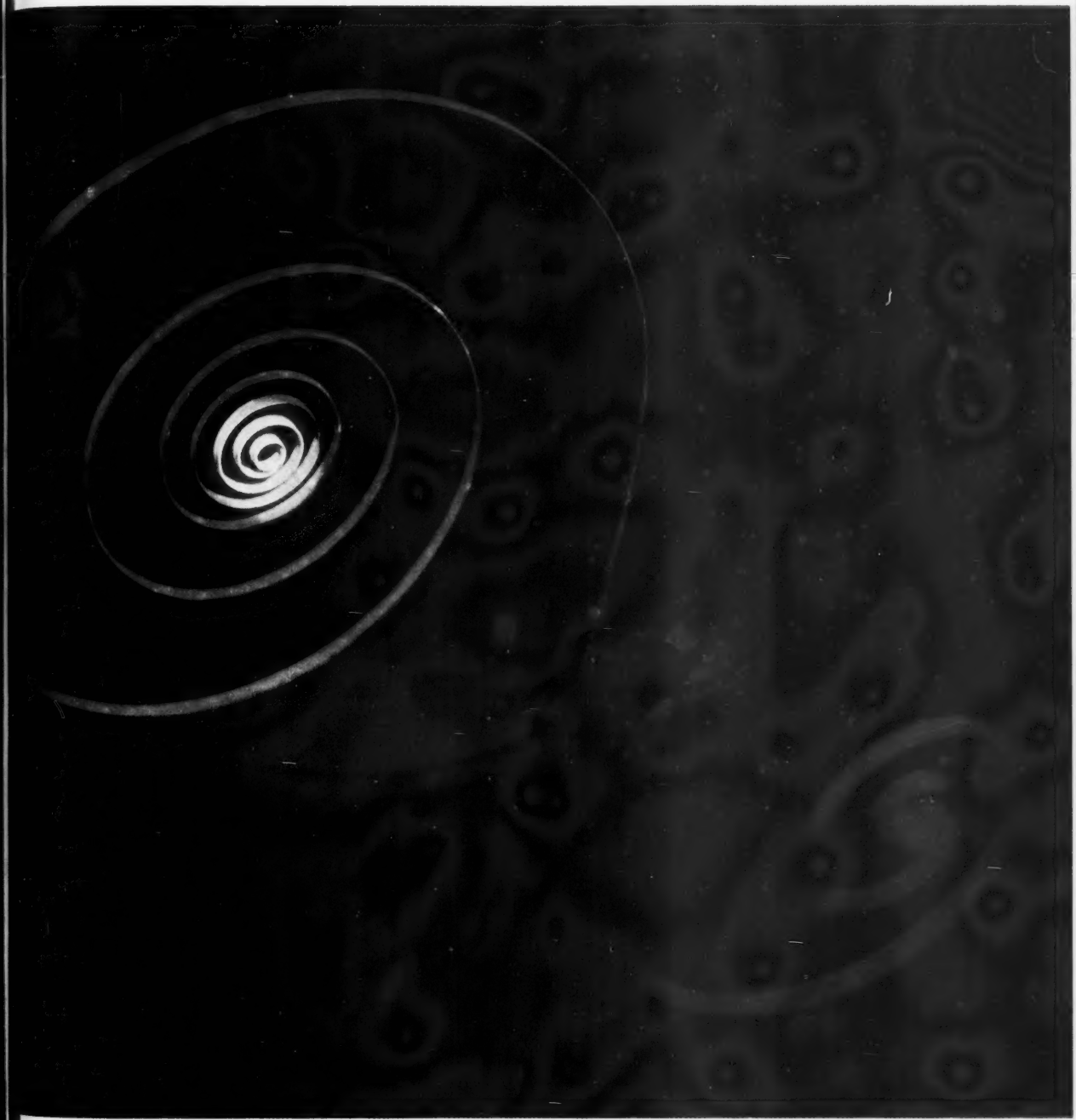
Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

NOVEMBER 1959



1959 ASTRONAUTICS ANNUAL

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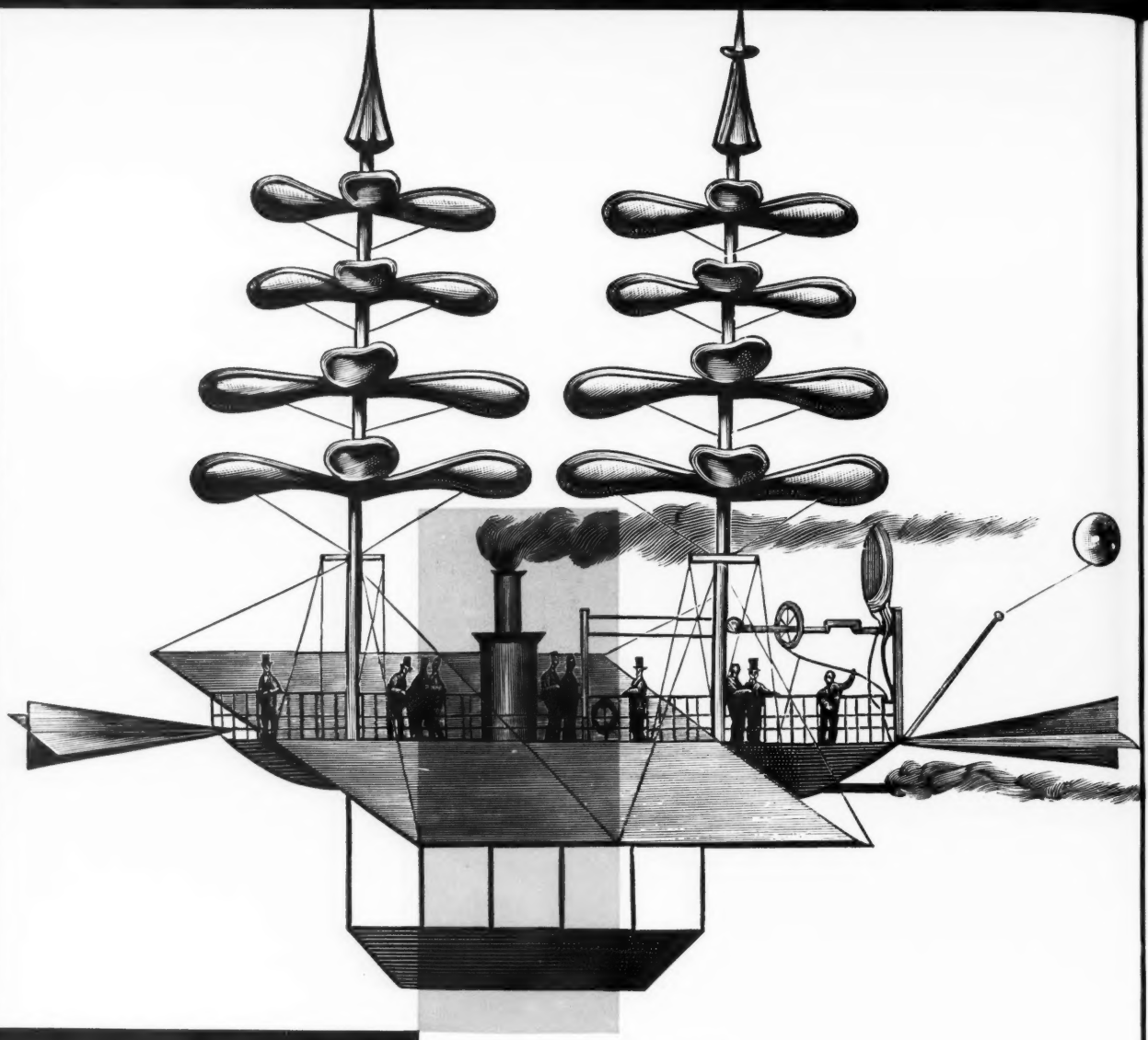

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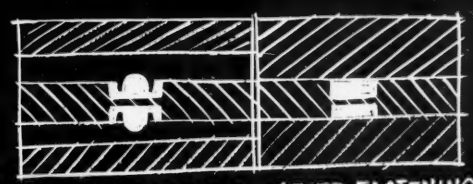

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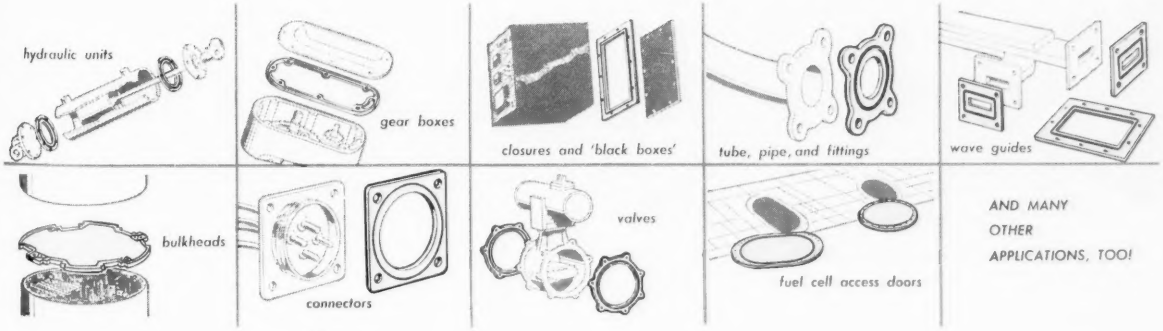

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November 1959 volume 4 number 11

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Astro notes

RUSSIAN MOON SHOTS

• Second scene, the same as the first. October 4: The Russians launched Lunik III, a 958-lb instrumented probe, on a trajectory that passed within a reported distance 4375 miles of the moon and looped around it on the start of a giant arc back to earth. The moon-skirting probe, reaching a maximum distance from the earth of approximately 292,000 miles on Oct. 10, returned to the vicinity of the earth Oct. 18 and went into an orbit that will bring it around the earth twice a month. Before, an official report from Moscow stated that contact with the probe Oct. 6 confirmed that instruments, thermal-regulation, transmission, and power-supply systems were operating normally. Scientists at Jodrell Bank, which tracked Lunik III, reported erratic radio signals as the probe began its swing behind the moon.

• Mid speculation that Lunik III missed an exact rendezvous by a little less than 3 hr, a conclusion offered by C. A. Whitney of the Smithsonian Astrophysical Observatory, the Russians announced that they would soon release photos of the moon's far side taken by the probe.

• Meanwhile, Lunik II, launched Sept. 14, gave evidence that the moon lacks a magnetic field. This finding lends support to the theory that the earth's magnetic field arises from convection currents in its highly pressurized molten core. It also suggests that the moon is largely silicate rock surrounding a now-cooled metal nucleus. Besides this detection, Lunik II collected and measured particles and ionized gases along its trajectory, measured radiation intensity, both within and outside the Great Radiation Belts, and took counts of micrometeorites.

• Concerning the data taken by Lunik II, Y. K. Federov, corresponding member of the U.S.S.R. Academy of Sciences, at a press conference in Moscow on Sept. 15, said that Soviet scientists are prepared to submit all information obtained during the probe's flight to scientists of other countries. The Russians have been noncommittal about data from Lunik III.

• Lunik II appears to have followed very closely its expected trajectory. In a Moscow release dated Sept. 15, L. I. Sedov, recently elected president of the IAF, stated that radio data positioned the impact of Lunik II in the region of the Sea of Brightness, within 200–300 km of the expected impact point. If not a fluke, this performance was impressive.

• "There can be little doubt at this point that Soviet space exploration is advancing rapidly according to a logical and well-ordered plan." Thus began F. J. Krieger of the Rand Corp. in his article, "The Soviet Astronautical Program," in the July 1959 *Astronautics*. The prospects for that program loom large indeed after the recent Luniks. The projects outlined by Dr. Krieger were iterated by V. V. Dobronravov, a frequent Russian commentator on Soviet space work, shortly after the launching of Lunik II—more satellites, a series of moon probes leading to a manned landing, and probes to Mars and Venus as soon as radio communication equipment has been perfected.

REACTIONS TO LUNIKS

• The two spectacular Russian moon shots raised a chorus of grumbling over the pace of the U.S. space program along with gloomy appraisals that the U.S. is now further behind the Russians than it was two years ago when Sputnik I captured the world's imagination. Since it is just such an atmosphere that produces hasty decisions and ill-advised programs, it is important to determine exactly what the Russians have accomplished and what the U.S. can reasonably do to buttress its own space prestige.

• To indulge in speculation for a moment, suppose the Russians had deliberately aimed Lunik II at the dead center of the moon. If it actually impacted at a point only about 270 miles from the center, this would amount to an error of 0.07 deg, or 4 min of arc. Translating this into ICBM terms for a range of 6000 miles, this would amount to a combined error of approximately 7.3 miles. This would represent a respectable ICBM performance, quite close to the desired ICBM mean circular error of 5 nautical miles.

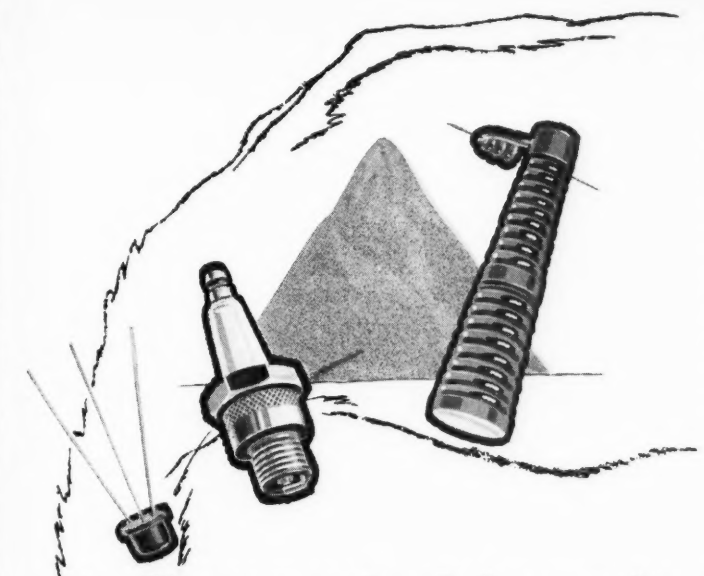
• The Lunik III circumlunar shot of early October represented a sterner test of a guidance system, according to studies by the Rand Corp., because very small velocity errors can be magnified enormously over the long flight-time of such a vehicle. Based on the initial Russian calculation that the vehicle would approach to within 1200 miles of earth upon its return trip, and the later modification of this prediction to about 24,000 miles, it appears that the vehicle did suffer from a substantial velocity error. According to rough estimates, a circumlunar shot of the type carried out by the Russians could absorb a velocity error of 20 fps, or something slightly more, and an angular error of about 0.5 deg.

• Thus, the performance of the Soviet moon shots are not unusually significant from a military standpoint, beyond proving once again that the Russians have a very large and reliable rocket at their disposal. The trouble is, they are using it in a methodical program which is racking up one dazzling space triumph after another. Not only is this a bitter pill to the U.S., accustomed to technological superiority in all things, but there is a genuine fear in Washington that Soviet space triumphs will help the Russians accomplish Cold War objectives without Cold War methods.

• As a result, there are many who would like to see new life pumped into the American program—more money for bigger projects, a single space "czar" to coordinate all the programs, and perhaps a special "Prestige Division" to handle spectacular space projects. NASA Director T. Keith Glennan is opposed to such measures, arguing that NASA is keenly sensitive to the prestige implications of spaceflight and that the only way the U.S. can capture the space lead from the Russians is through a systematic development program leading to the vehicles and systems needed.

• Probably few would argue that payload weight per se is the criterion of excellence in space activity. As Herbert York, DOD Director of Research and Engineering, has observed, the Russians will be able to send twice as much payload on any given mission as the U.S., at least until the million-pound-thrust engine becomes available several years from now. He argues that the important thing is what you accomplish in space within your weight allowance.

• The question, then, is when can the U.S. expect to have a booster



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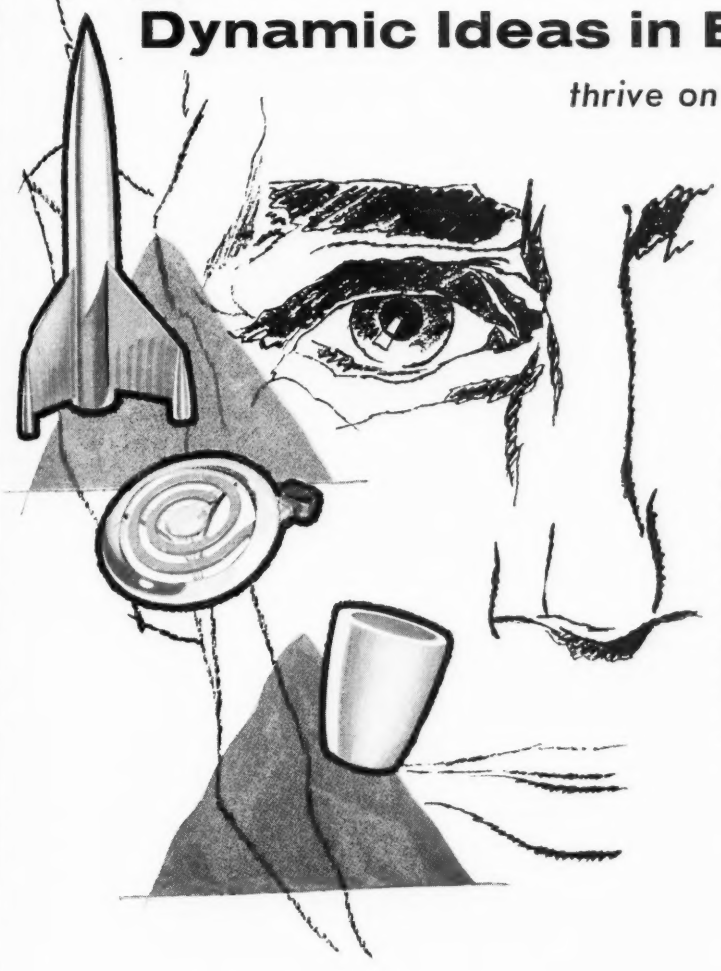

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available for lunar shots of the type carried out by the Russians? Not until late 1960 will we have the Atlas-Vega combination, which will be able to match current Russian payload weights (5000 lb in orbit, 1300 lb for a space probe or circumlunar flight, and 980 lb for a moon orbiter). About a year after that will come the Atlas-Centaur, with about a 40 per cent greater capability because of its high-energy second stage. Few Americans want to wait this long, however, and there is an earlier vehicle: The Atlas-Able. By a cruel blow of fate, the first of these systems exploded during a Cape Canaveral static-firing in preparation for a moon-orbiting attempt, but the fact remains that the vehicle is available for such projects.

• For example, in October 1960, Mars will be in a favorable position for an interplanetary-probe shot. A U.S. Mars probe at that time might go far toward restoring this country's space prestige.

• Meanwhile, rumors continue that NASA will attempt a moon orbiter and a deep-space probe toward Venus late this month with the Atlas-Able booster system.

SPACE REORGANIZATION

• As announced by Secy. of Defense Neil McElroy, the Advanced Research Projects Agency will gradually withdraw from most of its space activities, shifting them to the individual military services. The key shift is the planned assignment to the Air Force of responsibility for the development, production, and launching of all space boosters for DOD. Development responsibility for payloads will be assigned separately, with the following assignments already made: Midas infrared early-warning satellite and Samos (Sentry) reconnaissance satellite, AF; Transit navigation satellite, Navy; and the early stages of the Notus communication satellite program, including the Courier, Army.

• The shakeup removed the Army from the spaceflight picture. This was acknowledged by Army Secretary Wilber Brucker, who expressed the hope that Wernher von Braun and the rest of his team at ABMA would be maintained intact. Though ABMA's disposition was still in doubt early last month, a White House decision appeared imminent. Most likely was its transfer to NASA, a move proposed and rejected last year.

• Also in doubt was the future of the Saturn program, which is to provide the clustered million-pound-thrust rocket booster. Few believed that the AF would assert a requirement for the engine, although a later phase of Notus (Task Decree) envisages its use to place large communication satellites in "stationary" orbits at 22,300-miles altitude. Saturn's fate appeared equally uncertain if it were transferred along with ABMA to NASA. Top officials of the civilian space agency are not kindly disposed to Saturn because they believe it duplicates their own Nova, the single-chamber engine which North American is developing.

• Air Force's Air Research and Development Command also announced an extensive in-house reorganization designed to regroup its centers and subcommands along more functional lines. A new Wright Air Development Div. will be established, to include the Directorate of Systems Management and major elements of the Wright Air Development Center. It will be responsible for all aeronautical systems. The Cambridge Research Center will form the nucleus of another new division to assume direction of all research on USAF communication and electronic-control systems. A third AF research division to be established in Washington to direct all basic research work will include the Office of Scientific Research and other elements of ARDC. The Ballistic Missile Div. remains unaffected as the fourth ARDC division.

SATELLITES

• Important new data on the structure and composition of the Great Radiation Belts have been obtained by the Explorer VI "Paddlewheel" satellite. Radiation experiments aboard the far-ranging satellite have confirmed James Van Allen's picture of two separate belts as far as low-energy particles are concerned. At higher energy levels, however, there would appear to be only a single belt of particles, with peak intensity at 1240-miles altitude and gradually falling off to the cosmic-ray background level.

• John Simpson of the Univ. of Chicago reported the discovery of a thin belt of energetic protons with a peak intensity of 1400 counts per square centimeter per second at 1240 miles. This band is located on the inner face of the lower of the two Van Allen radiation belts, which extends from 1400- to 3400-miles altitude at the geomagnetic equator. (Simpson's multidetector "telescope" secured its readings about 20 deg from the geomagnetic equator.)

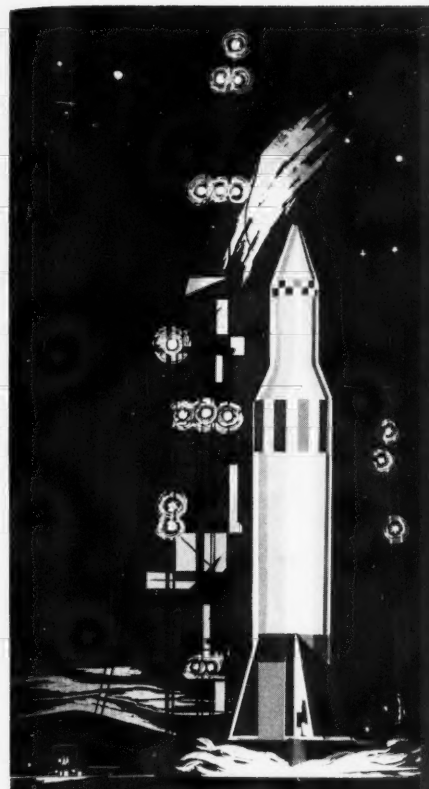
• With an energy level in excess of 75-million ev, the protons of the "Simpson Belt" represent the most penetrating of all the particles trapped in the earth's geomagnetic field. Although difficult to shield against, the number of energetic particles is sufficiently small to limit the radiation exposure level to only a few roentgens per hour. The more serious radiation threat still stems from the vast flux of low-energy electrons in the outer Van Allen belt, but these can be readily shielded—perhaps by the structure of the space capsule itself.

• John R. Winckler of the Univ. of Minnesota reported that the shielding on his instruments (equivalent to 0.5 grams of lead per square centimeter, or about 0.25 in. of water) cut the radiation dose from these particles to a level of 7 r/hr in times of low solar activity and to 30 r/hr at times of high activity. These particles have a flux of about 100,000,000 per square centimeter, in contrast with the much lower flux of Simpson's protons.

• Dr. Winckler also confirmed the Van Allen report that the radiation level in the outer belt fluctuates within wide extremes. When the Paddlewheel was launched in early August, the radiation intensity in the outer belt was 5000 times less than that found by Pioneer IV last March and 10 times less than that detected by Pioneer III last December. By the end of August, following a solar storm about the middle of the month, the outer belt filled up again to the level detected by Pioneer III, thus showing its dependence upon soft electrons from the sun.

• There are indications that Explorer VI safely traversed the Perseid meteor stream on Aug. 7 and 8, since it registered micrometeorite hits at twice the usual rate during these days, with a rate of onset and decline conforming closely with the Perseid shower. A total of 56 hits by particles larger than about 1.8 microns were recorded between Aug. 7 and Sept. 1 by the satellite's microphone detector, plus two hits by particles considered to be larger than 4.4 microns.

• Despite several malfunctions, the Paddlewheel is regarded as "highly successful" from a technological



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standpoint. Malfunctions include the loss of one paddle and its solar cells, which reduced its power generation to about 65 per cent of the expected 26 watts during its first month in orbit, and the failure of one of the two low-powered transmitters broadcasting on 108.6 mc. The latter occurred about 35 days after launching, and meant the loss of the radiation experiments conducted by STL as well as the "triplet" count of the Univ. of Chicago experiment.

• Theoretically, the lost information could be secured through the digitalized 378-mc transmitter, but the latter has been limited to a broadcast time of 25 min per day by the power shortage. (Four hours per day was the goal.) The power output of the remaining three cells is expected to improve after Jan. 1, perhaps to as much as 85 per cent of the amount expected, when the paddles assume a more favorable aspect with the sun. NASA engineers also believe that interrogation time on the large (5-watt) transmitter can be boosted to as much as 1.5 hr per day by turning off the remaining 108-mc analog transmitter during periods when its information cannot be recorded by ground stations.

• Although temporarily balked in deep-space ventures, the U.S. will mount a concerted and constantly expanding attack on near-space with satellites during the coming year. These will include several of NASA's newly announced gyro-stabilized solar platforms, which will carry a spectrometer for sun studies and perhaps provisions for picking up radio emissions from the sun; two satellites for ionosphere study; and several more paddlewheel vehicles. Homer J. Stewart discusses NASA plans on page 24; George Sutton covers DOD projects on page 26.

• Lockheed Missile and Space Div. has selected the Space Communications Div. of Radiation Inc. as a major contractor for the development of the Lockheed master satellite control center at Mountain View, Calif. This center will monitor and evaluate data from a worldwide tracking network. It will include a hot-line communication system to tracking sites, launching stations, BMD, the air-rescue service, and other government and military groups.

• NASA announced that the first of an undisclosed number of additional satellite-tracking (Minitrack) stations will be established in Minnesota, near East Grand Forks.

• Explorer VII, the 91$^1/_2$-lb satellite prepared and launched by ABMA for NASA on Oct. 13 with a Juno II four-stage rocket assembly, carried experiments on earth radiation balance, Lyman-Alpha and soft X-ray radiation, heavy primary cosmic rays, micrometeorite distribution, solar-cell, functioning, and satellite-temperature history. The satellite went into an orbit with an initial apogee of 680 miles and perigee of 346 miles, quite near the scheduled one.

MAN IN SPACE

• The Soviet magazine *Ogonek* recently revealed for the first time the existence of a cadre of Russian astronauts and means being taken to train them. Ogonek showed pictures of spacesuit-clad pilots undergoing conditions of explosive decompression and centrifuge g-conditioning. According to a *London Daily Herald* report from Moscow, some 20 Russian astronauts have been in training for spaceflight for more than two years. The *Herald* also reported that Soviet scientists believe they can now send a manned rocket to an altitude of 200 miles and bring the pilot back alive, and gave next spring as a probable time for the first Russian manned spaceflight.

SPACE RESEARCH

• The Navy announced the successful completion of two solar research projects: Edward P. Ney's expedition to Africa to obtain data on the Oct. 2 eclipse of the sun, and Herbert Friedman's Sunflare II project to measure the sun's output of X-rays during intense solar flares. Dr. Ney's group conducted a series of unprecedented measurements with coronal polarimeters to determine the polarization of the corona. Dr. Friedman and Dr. Talbot A. Chubb detected X-rays with energies as high as 80,000 ev, indicating temperatures as high as 100 million C in the solar atmosphere. They performed their measurements with 12 Nike-Asp rockets launched from Point Arguello, Calif. Eight of the vehicles were entirely successful, carrying 55-lb payloads to altitudes of 130–150 miles and telemetering up to 8 minutes of data on the best flights.

• Aerojet-General Corp. reported receipt of a USAF contract to build four Astrobee-500 rockets. These are three-stage fin-stabilized vehicles designed to carry a 70-lb payload to 450 miles. First of the 25-ft rockets will be launched at Eglin AFB this year. Aerojet has also said it is working on a sounding rocket called the Astrobee-1000, but gave no details.

• ARPA has authorized construction of a huge radar installation in Puerto Rico for use in the Defender program. With a diameter of 1000 ft, the instrument is the largest known to be under construction in the West. Cornell Univ. will design and build the unit for ARPA, which will use it to study ballistic missiles during midcourse. It will also be able to measure electron densities to a distance of one earth radii, as well as detect auroral ionization and streams of particles in space. One of its most exciting possibilities lies in the field of radio-astronomy—obtaining radar echoes from Mars and Venus and mapping the moon and sun. Its tropical location will facilitate such studies, for all the planets of the Solar System lie close to the earth's equatorial plane.

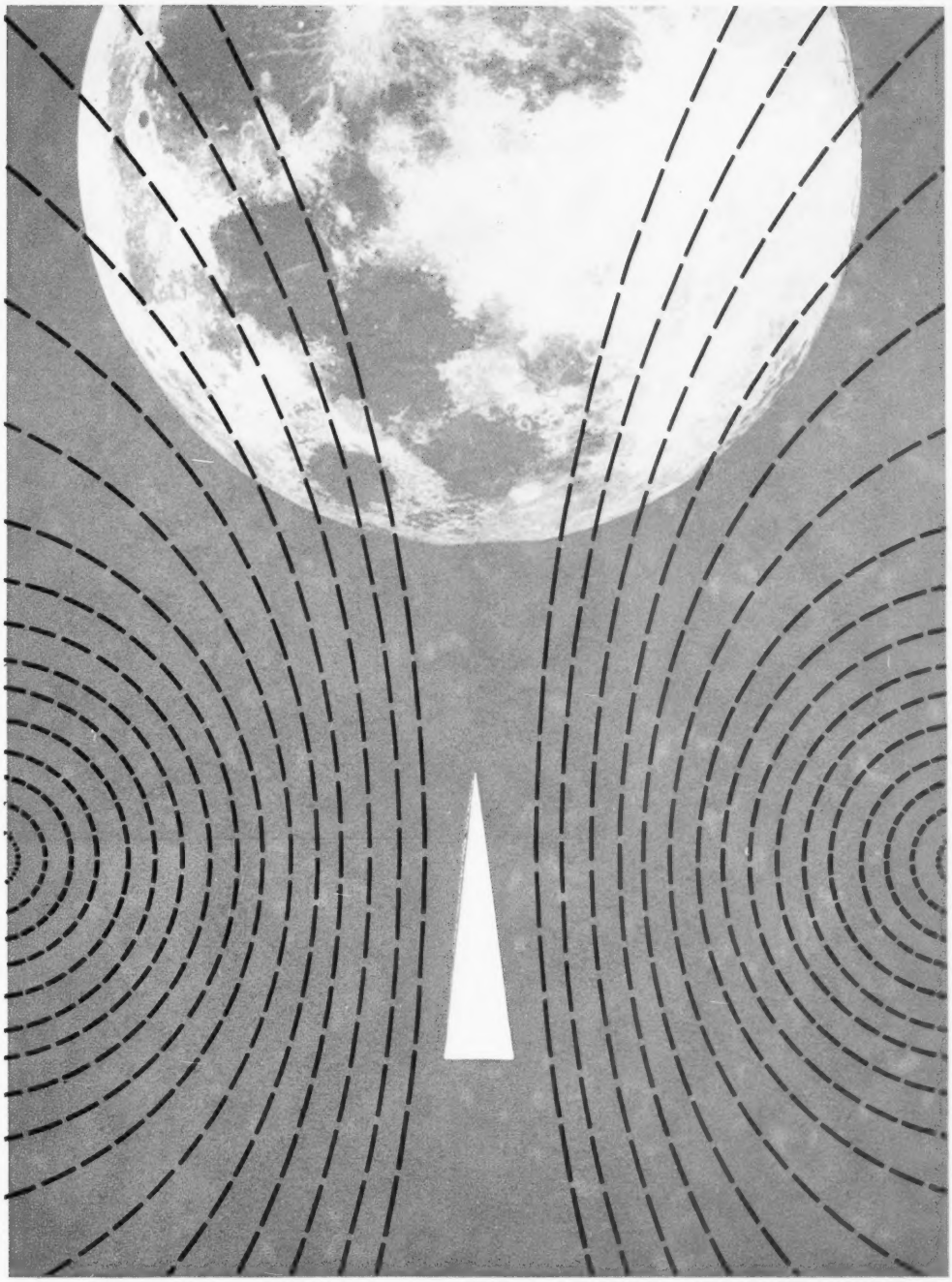
• NASA is negotiating a contract with Lockheed Aircraft Corp. for a three-year feasibility study of nuclear-rocket systems with NASA's 60-megawatt research reactor at Plum Brook, Ohio. A principal objective will be the investigation of the behavior of nuclear-rocket materials at cryogenic temperatures while undergoing neutron bombardment.

• "The necessary instruments for thorough exploration of space are not on the drawing boards at the present time," according to Thomas Gold, chairman of the Dept. of Astronomy at Cornell Univ., citing what he considers a lack that can be remedied in the U.S. space program.

• The Univ. of Michigan has dedicated the first steerable radio telescope designed especially for solar research. A 70-ton instrument built with ONR support, it can resolve in finer detail than the Jodrell Bank telescope solar short-wavelength radio emissions.

• The moon seismograph being studied by Columbia Univ. and CIT under the sponsorship of NASA is expected to weigh about 20 lb.

• NASA plans to launch an atomic clock into a heliocentric orbit are expected to show results early next year. (CONTINUED ON PAGE 12)



Avco's magnetic spaceflight—

When man first travels beyond the moon, the thrust may well be supplied by a new system of propulsion, based on principles of magnetohydrodynamics (MHD). This system uses a magnetic field to speed and expel ionized gas for power output. Magnetic thrust propulsion is a current project of the Avco-Everett Research Laboratory . . . working to extend the knowledge of man.

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The Marquardt Hyperjet combines both rocket and ramjet in a single, integrated engine system — producing maximum performance from both. It is an engine with controlled rocket thrust for static launch, boost, operation in space and re-entry. It is an engine utilizing the ramjet's superior specific impulse for acceleration and hypersonic cruise within the earth's atmosphere.

From earth to orbit, the Marquardt Hyperjet delivers twice the average specific impulse of today's best rockets, permitting heavier payloads at minimum cost. Yet this same, single propulsion system outperforms any other for hypersonic flight within the atmosphere — shrinks both size and weight of the vehicle required to deliver any given payload.

This, then, is the Marquardt Hyperjet: a new propulsion system with applications to small and large vehicles — manned and unmanned — ground- and air-launched — for operation in and/or out of the earth's atmosphere.

If you have an applicable mission — and the need to know — you are invited to contact: Paul J. Papanek, Director of Marketing, Power Systems Group, 16555 Saticoy Street, Van Nuys, California.

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Engineers and Scientists capable of contributing advances in state-of-the-art are invited to write: Manager of Personnel Development, Power Systems Group, 16555 Saticoy St., Van Nuys, Calif.

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Imagine missions at speeds beyond those of any turbojet — involving smaller and lighter vehicles, longer ranges and heavier payloads than those possible with today's rocket engines. These are missions for the Marquardt Hyperjet.

The Marquardt Hyperjet combines both rocket and ramjet in a single, integrated engine system — produc-

MISSILES

• The Bold Orion test missile, fired from a B-47 at the Explorer VII satellite as it hit perigee over the Atlantic Missile Range Oct. 13, was reported to have passed within 4 miles of the satellite. The success of this experiment appears to give the AF and the Martin Co. a strong argument for an air-launched anti-satellite missile.

• The over-all U.S. ballistic missile program now provides for almost 500 ICBM or ICBM-equivalent weapons by the end of 1963. A breakdown discloses 12 Atlas squadrons (120 weapons), 11 Titan squadrons (110), five Thor and Jupiter squadrons (50 missiles) stationed in Britain and Italy, two squadrons of Minuteman (100), and a Polaris submarine capability of about 100 missiles on station. Common to all the weapons will be the capability of reaching targets in Russia.

• Also, although only partially funded, the total AF program now provides for a total of 804 Minuteman weapons, including 54 on railway cars and the balance in hardened underground silos.

• The AF chose Beale AFB, Calif., as its fifth operational site for the Titan ICBM. It said the installation will cost $42 million and takes 22 months to build. The previously announced facilities at Ellsworth will cost approximately $47 million, and 20 months to complete.

• Aerojet has received a $56,000 Army contract to study the feasibility of individual rocket lift devices for combat troops. It provides for a system analysis to the company's own design, the AeroPak, with consideration of the rockets' size, weight, location, number of nozzles, flight duration, maximum velocity, effects of wind gusts, loss of stability, and rocket malfunction.

• Goodyear Aircraft Corp. announced the development of a new all-weather guidance system for aircraft and missiles. Called Pinpoint, it is an outgrowth of Goodyear's Atran map-matching guidance system devised for one version of the Martin Mace. It is coupled with inertial elements for dead reckoning during long flights over water when the map-matching system has no landmarks to work on. Similar to the "AtraNertial" system proposed for the defunct Regulus II, the guidance system, Goodyear reported, is being evaluated "for a number of weapons systems."

• As expected, burgetary pressures forced AF cancellation of the Mach 3 F-108 interceptor. The action forced North American Aviation, to drop 2000 workers, half in Los Angeles and the other half in Columbus, Ohio. The company said its fiscal 1960 sales will be reduced by 14 per cent, to an estimated level of $1.2 billion. North American said the action will not affect the B-70 bomber program. Latter is deemed solid for the time being, although some Washington observers believe it will eventually meet the same fate as the F-108 if North American's Hound Dog air-to-surface missile is successful. This 350-mile weapon may become operational next year.

• In the third successive failure in the Polaris flight-test program, the missile's second stage burned for only 8 sec and caused a short flight. Only 6 of 19 flights thus far qualify as successes.

• The Navy's plans for Polaris otherwise moved smoothly ahead with the launching of the second nuclear-powered Polaris launching sub, the USS Patrick Henry, and the announcement that it is building at Cutler, Me., the world's most powerful radio transmitter, which will be used to communicate with submerged Polaris subs. Through its huge antenna system, the facility will transmit with at least a million watts of power in the very low frequency band, from 3 to 30 kc, waves of which penetrate water to a certain depth.

• The AF announced that it was shifting Project Pluto to complete development status as Project Slam —a low-level, world-girdling, nuclear - ramjet - powered missile. Chance Vought has been studying the supersonic missile system for the AF. The Pluto propulsion system study has been a combined project of the AEC's Lawrence Radiation Lab at Livermore, the Atomics International Div. of North American, and Marquardt.

• The recent explosion of a mixing plant at Hercules Powder reportedly wiped out 40 per cent of the propellant-production capacity for Minuteman.

• Perkin-Elmer's West German subsidiary, Bodenseewerk, will have full responsibility for the NATO Sidewinder production program in Europe, and will handle directly about a third of the production of guidance systems and assembly and test of missiles under a $30 million contract.

• A second free-flight test of Nike-Zeus at White Sands in October gave the Army encouraging results, the first and second stages of the developmental anti-ICBM performing acceptably. A reappraisal of the Nike-Zeus system is scheduled for presentation to the President some time after budget submittal to Congress in January, when new funding for the missile could be requested.

• Western Electric received a $188,402,905 contract from the Army for Nike-Zeus R&D. DOD officials have estimated that it would cost a total of 8 to 10 billion dollars in R&D costs alone to establish 40 to 50 Nike-Zeus sites.

MATERIALS

• At its fifth annual titanium conference, New York Univ. announced that it has developed a new titanium alloy far superior in strength, ductility, and toughness to any comparable one commercially available. Nominal composition: 6 per cent aluminum, 6 per cent vanadium, 2 per cent tin, 0.5 per cent iron, 0.25 per cent copper, and 85.25 per cent titanium. The alloy has been tested extensively at NYU and Watertown Arsenal Laboratories, which sponsored the development.

• GE's Flight Propulsion Laboratory at Evandale, Ohio, has developed refractory cerium sulfides for use as core material in the casting of openings or channels in high-temperature and heat-resistant materials.

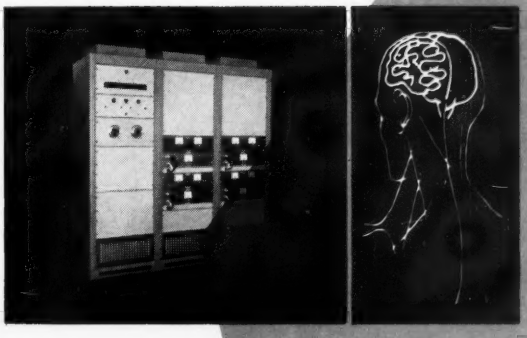
• Crucible Steel has received an AF contract to develop a manufacturing process for rolled columbium alloy sheet. Aiming at sheets 36 x 96 in., the program is expected to take two years. The sheet would be used as structure for hypersonic vehicles.

• Hughes Aircraft has developed a method for casting optical-quality silicon for infrared sensors. The process will permit volume production of missile IR lenses and domes.

INTERNATIONAL ROCKET WEEK

• The U. S. launches 10 high-altitude research rockets this month in support of International Rocket Week, Nov. 16–22, and as a continuation of IGY studies. The continuing U. S. IGY studies are under the direction of the National Academy of Sciences.

TO BETTER THE REAL THING



ERCO creates experience

A missile once launched is committed. The system required to accomplish this launching must be maintained at a level of peak effectiveness at all times.

Malfunction in time of need could spell disaster. Predetermination of possible malfunctions and the training of personnel to detect, analyse, and correct rapidly is essential to preventing systems failures.

Under contract to General Electric, ERCO has developed and built equipment to provide familiarization and proficiency training for Air Force crews who operate the Atlas ICBM guidance systems. This equipment has been designed to provide personnel with:

Basic Training in guidance system equipment... Overall familiarity with the system for each of the crew members... Recognition, analysis and correction of the system's malfunctions.

The ability of our modern weapons to fulfill their defensive missions rests largely on the men who operate and maintain these systems.

Training equipment systems, such as the one described, are designed to permit the man to live and re-live an experience hundreds of times before it happens.

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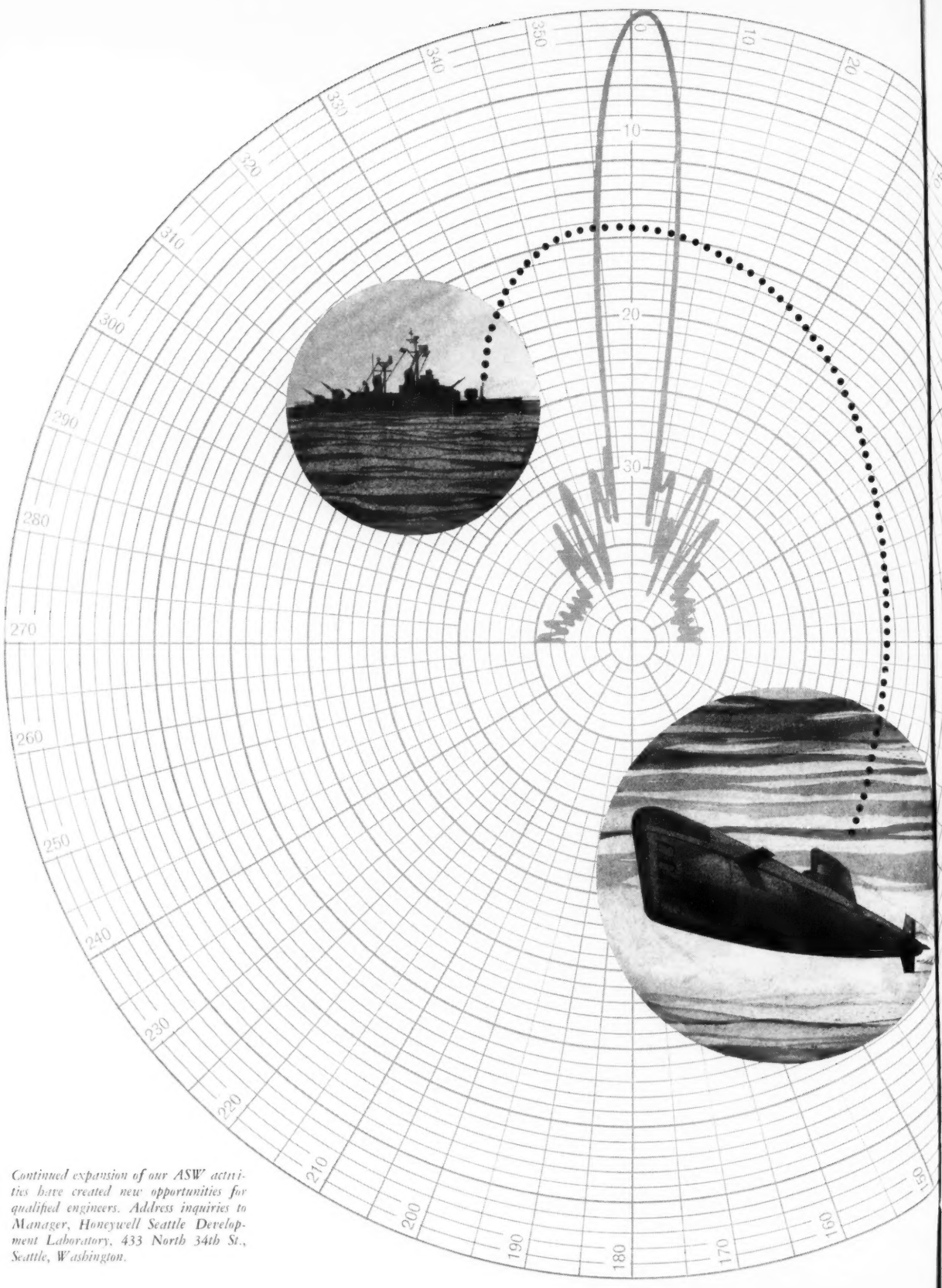
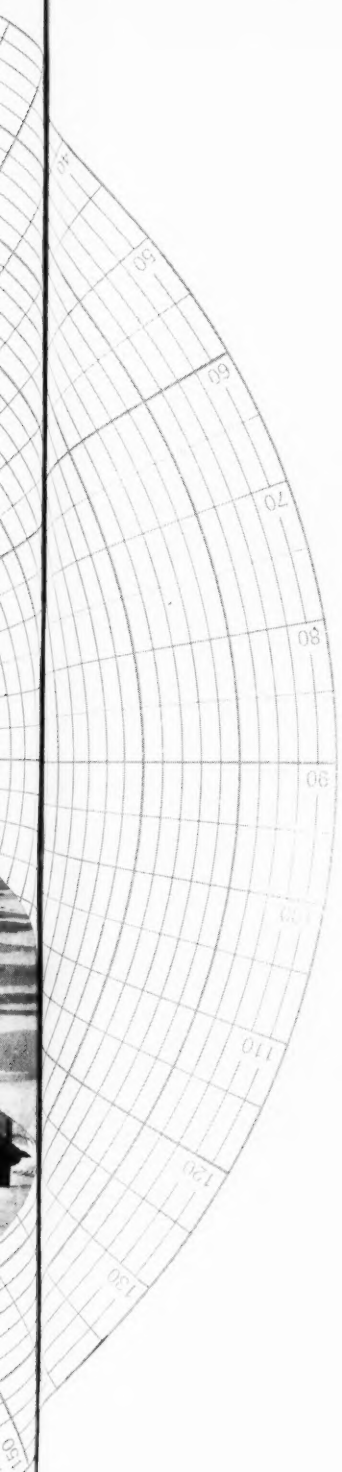


Continued expansion of our ASW activities have created new opportunities for qualified engineers. Address inquiries to Manager, Honeywell Seattle Development Laboratory, 433 North 34th St., Seattle, Washington.



Prime targets in the fight for improved anti-submarine warfare:

Search, Detection, Kill!

Anti-submarine warfare consists of six, easily-defined areas: search, detection, classification, localization, kill and assessment. Not so easy, however, is the job of implementing them. The United States Navy, with the help of private industry and other government research agencies, is making impressive headway on this ASW problem in many areas. Their target? Certain detection and continuous surveillance of any undersea threat.

Honeywell is pleased to participate in this intensive Naval effort with the following projects in research, design, development and production:

1 An anti-submarine missile, ASROC, that can be launched from a surfaced ship.

2 A shore-based ASW weapons system team trainer.

3 A new sonic sea range system that plots the hydroballistic trajectory of underwater weapons through a network of sonar buoys and mobile-based sonar.

4 A torpedo and submarine tracking system consisting of an ultra-sonic transponder that tracks the path of high speed torpedoes and subs.

5 A sonar training device for teaching trainees the proper action and response to sonar signals.

6 A number of fuzing and arming devices for mines that will insure detonation only on recognition of enemy ship's signatures.

7 A sonar target simulator capable of digesting radar and sonar target information and presenting this information visually aboard ship.

Honeywell provides full corporate support for Anti-Submarine Warfare with the facilities of 14 corporate divisions. An example of Honeywell's facilities is the ASW Research Ship "Neper" (right) based at our Seattle Development Laboratory. Here ASW systems are tested in actual environments of both fresh and salt water supported by complete test facilities, including instrumented barges.

If you have a problem in this important area of defense, write Minneapolis-Honeywell, Minneapolis 8, Minnesota.

Honeywell

H Military Products Group

For the record

The month's news in review

Sept. 1—AF reveals it successfully test-fired the XLR-99-RM-1 X-15 rocket engine.

—AF formally turns over management of operational Atlas to SAC at Vandenberg AFB.

Sept. 2—IAF appoints Theodore von Karman chairman of a committee to set up an International Academy of Astronautics.

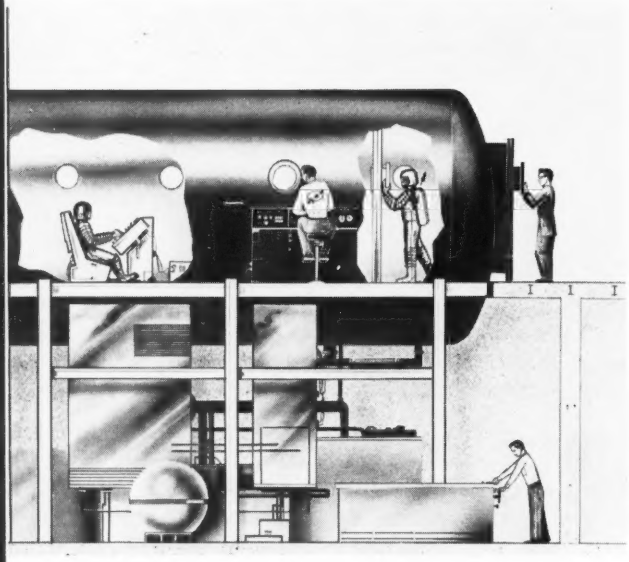
Sept. 5—AF discloses that F-100, aided by 130,000-lb-thrust booster, recently effected takeoff from a platform in less than an inch.

Sept. 9—NASA test-fires Big Joe space capsule more than 1500 miles into Caribbean and recovers it. AF report indicates the capsule attained 100-mile altitude, speed of 14,000 mph and reentered the earth's atmosphere with temperatures never rising above 100 F.

—SAC fires Atlas 4400 miles over Pacific Missile Range.

Sept. 12—U.S.S.R. launches lunar rocket with 858.4-lb payload.

—U.S. schedules lunar shot for Oct. 3–6.



"150 Miles High" Simulator

Republic Aviation plans an environmental testing chamber capable of simulating pressure and ionospheric conditions at an altitude of 150 miles for its new research center at Farmingdale, N.Y. The chamber will be 14 ft in diam and 30 ft long. Being built by Tenney Engineering of Union, N.J., the new facility is expected to be installed at Republic's research center in early 1960.

Sept. 14—Soviet Lunik II impacts on moon.

—Soviet scientists say no territorial claims on moon will be made as a result of the flight.

Sept. 15—AF successfully fires full-sized mockup of Minuteman from underground launching pad at Edwards AFB.

Sept. 16—Army Jupiter containing mice and frogs is blown up soon after launch.

—AF successfully launches Atlas.

Sept. 17—X-15 makes first powered flight, attaining speed of about 1400 mph.

—NASA discloses plans to set up Minitrack station near East Grand Forks, Minn.

—AF Thor-Able navigation satellite fails to orbit.

Sept. 18—Navy launches last Vanguard into orbit.

Sept. 20—DOD reveals AF has ordered development of nuclear ramjet engine.

Sept. 21—NASA says first American Astronaut will go from short-range test flights in Redstone rockets to full-scale satellite launchings with Atlas.

—Soviet scientists say data from recent lunar shot fails to reveal either a magnetic zone or a radiation belt around the moon.

—AF announces plans to study the stars from stabilized platforms 10 miles above the earth.

Sept. 22—U.S. launches missile-firing atomic sub, Patrick Henry.

Sept. 23—DOD assigns top role to AF in reorganized space program.

—AF cancels F-180 development program.

Sept. 24—AF Atlas-Able explodes during static-test, causing postponement of scheduled moon shot.

—Navy proposes unified military space and missile development command under Joint Chiefs of Staff.

Sept. 25—AF Snark fails in launching test as result of ignition trouble.

Sept. 26—National Radio Astronomy Observatory reveals one of its scientists has charted the heart of our galaxy and found four centers of intensity.

Sept. 28—NASA reports that Explorer VI, paddlewheel satellite, has transmitted TV pictures of the earth, and also has discovered new belt of radiation underlying the inner Van Allen belt.

—Navy Polaris prototype fails.

Sept. 29—Navy says data from Project Sunflare indicates solar temperatures may run as high as 190 million F, about 10 times hotter than previously estimated.

Sept. 30—AF Arcas hurls 3-ft plastic balloon 235,000 ft above Cape Canaveral.

MOON GARDEN

You can't grow anything on moon soil . . . but Republic is . . . raising turnips, carrots, beets and snap beans in its lunar greenhouse experimental garden. ➤➤➤ Republic is working on lunar garden studies as part of a research program to determine the feasibility of establishing a base on the moon. ➤➤➤ Hyman Stein, manager of space projects and studies for Republic's Applied Research and Development Division . . . and his "green thumb staff" (Bill Taufman seen here), maintain a constant, studious vigil over these tests. ➤➤➤ A basic aim is to determine at how low a pressure vegetables can be grown to maturity. The lower the pressure, the less weight of the greenhouse structure. And weight is critical in delivering a payload to the moon. ➤➤➤ These experiments will determine whether significant increases in crop production can be obtained by lengthening the working day as past tests indicate. Our Moon Garden studies are but one of many bold concepts under development as part of Republic's multi-million dollar exploration into the realm of advanced aircraft, missiles, space travel and space.

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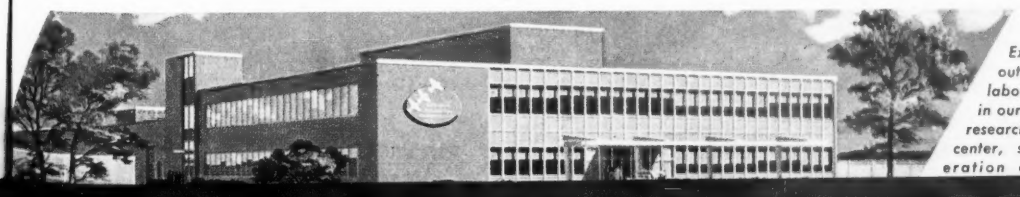
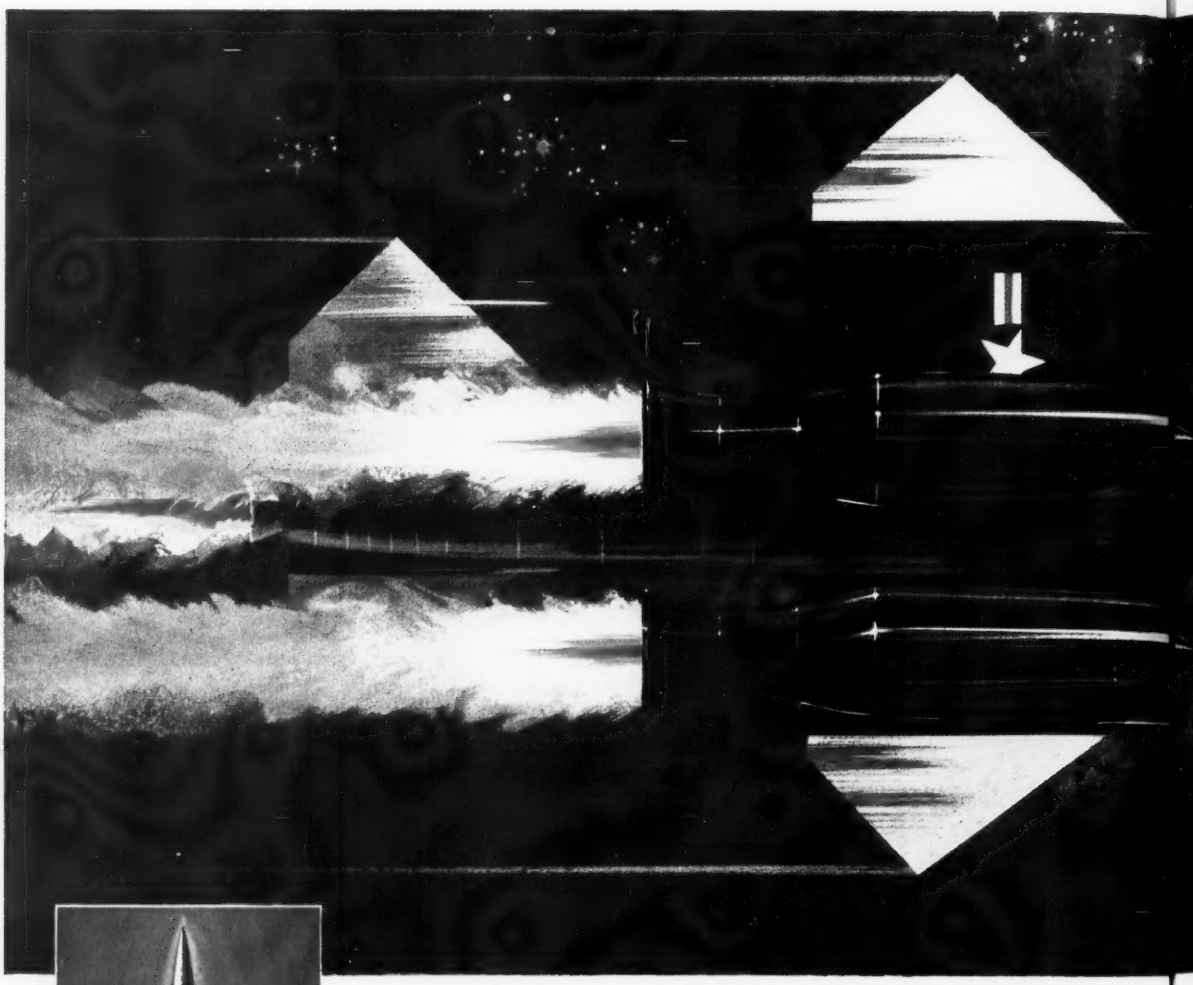


Experiments being carried out in Republic's preliminary laboratory will be housed in our new 14 million dollar research and development center, scheduled for operation early in 1960.



Keeping pace with the nation's missile
BOMARC "B" by BOEING. To be launched
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DISTANT INTERCEPT than earlier models

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Continued cooperative action by the military and thousands of contractors like THIOKOL Chemical Corporation and BOEING, whose contributions to the air age, jet age and space age are immeasurable, is vital to America's defense.

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PILOTLESS AIRCRAFT DIVISION SEATTLE, WASHINGTON

International scene

By ANDREW G. HALEY

The ITU Conferences and Astronautical Radio Allocations

Delegations from 88 nations are now gathered in Geneva under the auspices of the International Telecommunication Union (ITU) to attend three consecutive plenary conferences during which every aspect of radio service and science will be reviewed, and a completely new world treaty will be entered into and new regulations promulgated to implement the new treaty. One of the most important problems taken up at the meeting is that which deals with providing radio frequencies for astronautical communications and research.

As a representative of ARS and IAF, the writer was privileged to address a plenary meeting of the delegates Sept. 18. Excerpts from this address may serve to summarize the current status of astronautical radio.

° ° °

The IAF initiated its program for the development of a plan to control the use of radio in outer space with a formal proposal to the ITU dated April 16, 1956. The IAF urged that working arrangements be set up between the IAF and the ITU "looking toward the optimum plan for allocation of frequencies in the radio spectrum for . . . communications in outer space."

The IAF proposal contained a five-point plan along the following lines:

1. The International Radio Consultative Committee (CCIR) of the ITU should study the *requirements* of radio in space.

2. The International Frequency Registration Board (IFRB) of the ITU should study the *frequencies* available to meet the requirements developed by the CCIR.

3. The IAF should send representatives to the sessions of CCIR and the IFRB.

4. The ITU should send representatives to IAF meetings—including the Rome Congress on earth satellites and spaceflight in September 1956.

5. After completion of these four steps, the ITU should initiate formal steps to effect radio allocations for use in space.

The ITU responded negatively to the IAF proposal. On June 11, 1956, the Secretary-General of ITU advised the IAF that the Union viewed the matters raised by the IAF as appropriate for the administration of individual member nations.

° ° °

Thereafter the IAF renewed its proposals, both in presentations to the ITU itself and in proposals to the constituent organizations of the ITU. The first of the latter category to which a formal proposal was made was the CCIR.

On Sept. 3, 1956, the IAF submitted to the CCIR a proposal that CCIR establish a new Study Group for extraterrestrial communications. In this proposal, IAF reviewed progress up to that time in earth orbital satellite programs and in the development of cislunar and circumlunar space vehicles, and discussed the importance of radio communications and guidance in such spaceflight activities.

The IAF document concluded with the statement that CCIR was the only international body authorized to study the subjects of communications and guidance in extraterrestrial projects, and urged that such a study be completed and a report rendered in time for presentation to the ITU International Radio Conference of 1959 in Geneva.

The CCIR at its 13th Plenary Meeting in Warsaw on Sept. 13, 1956, responded officially to the IAF proposal by causing its director to suggest that the IAF apply for membership in the CCIR. The CCIR director did so, and suggested further to IAF that it choose from among the list of then-existing CCIR Study Groups the Study Groups in which it would desire to participate.

° ° °

The IAF's application for association with the ITU was filed on May 10, 1957. The IAF pointed out its interest in participating in all conferences related to the study of radio requirements and the allocation of frequencies to various activities in space.

The ITU Administrative Council, at its May 1957 session, voted to include the IAF in the list of international organizations to be notified of the 1959 Radio Conference and to be allowed to participate therein.

A letter was sent by the IAF to the CCIR on Aug. 7, 1957 stating that the IAF was seeking "intelligent studies of the technical aspects of radio communication under operating conditions in spaceflight." The CCIR responded by noting that the IAF was admitted to participate as an international organization in the work of ITU.

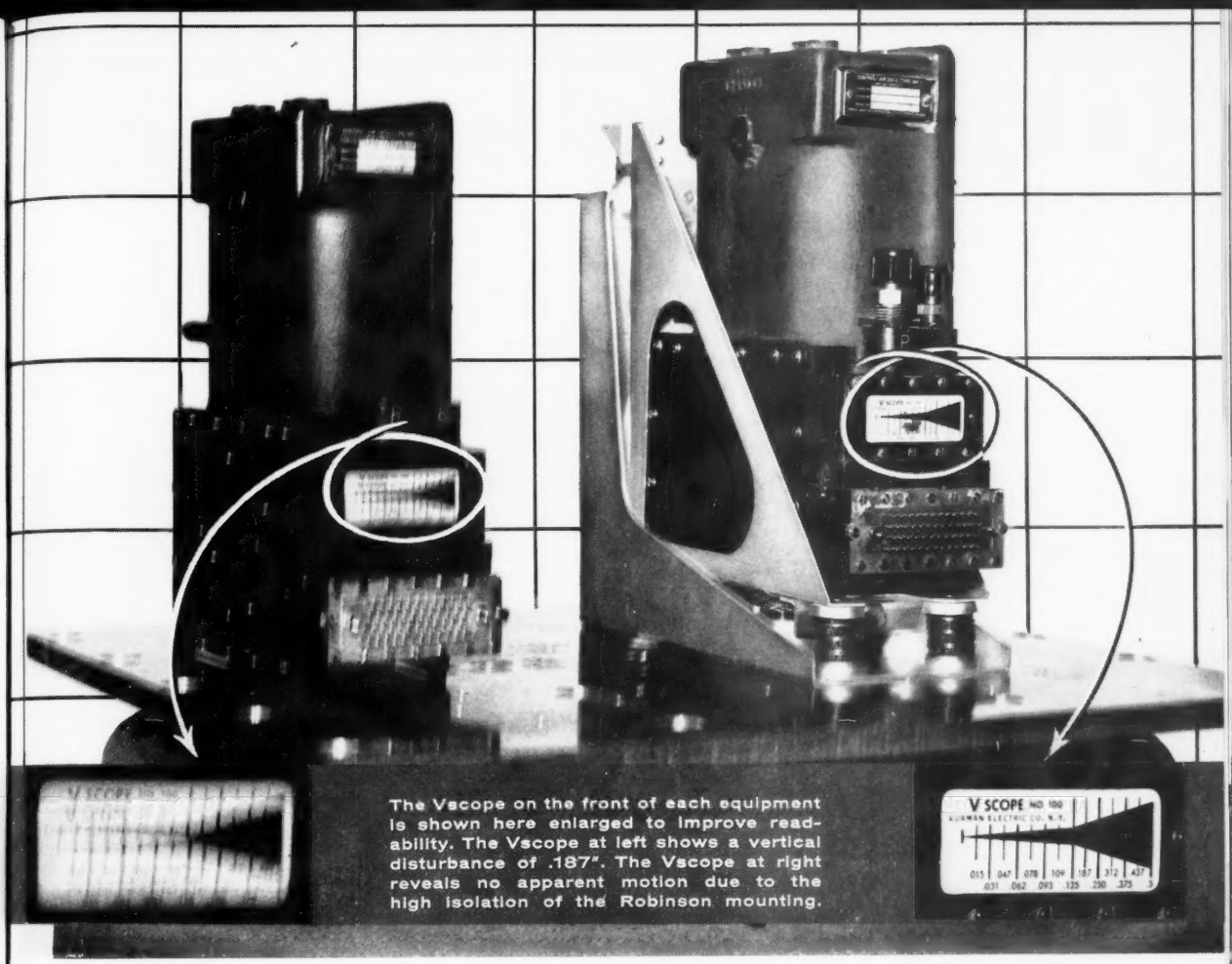
Thereafter, on Dec. 30, 1957, the IAF renewed its proposal that the CCIR set up a Space Communications Study Group, and also supplied the CCIR with copies of the ARS Appearance and Comments in the Federal Communications Commission's inquiry into radio allocations between 25 and 890 mc. (ARS is, of course, a member of IAF.)

° ° °

On April 12, 1958, the IAF advised the CCIR of its intention and desire to participate in two of the then-existing Study Groups of the CCIR most closely connected with the subject of radio communications in space. Thereafter, IAF was formally advised by the CCIR on April 18, 1958 that it would be allowed to participate in CCIR Study Groups VI (Ionospheric Propagation) and XI (Television).

(CONTINUED ON PAGE 62)

The author (right), ARS-IAF representative at the ITU Radio Conference in Geneva, exchanges a few words with Commissioner T. A. M. Craven (left), chairman of the Conference, and Col. R. B. Watkins, his administrative assistant.



The Vscope on the front of each equipment is shown here enlarged to improve readability. The Vscope at left shows a vertical disturbance of .187". The Vscope at right reveals no apparent motion due to the high isolation of the Robinson mounting.

12.0 "G" reduced to 0.6 "G"

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Look at the above illustration, showing two Bendix air data sensors on an electromagnetic shake table. Notice the left hand unit which is mounted solidly to the oscillating head of the shaker. The image is blurred because a vibratory input of about .187" double amplitude at 35 c.p.s., equalling an acceleration force of 12 "g's", is being applied directly to it.

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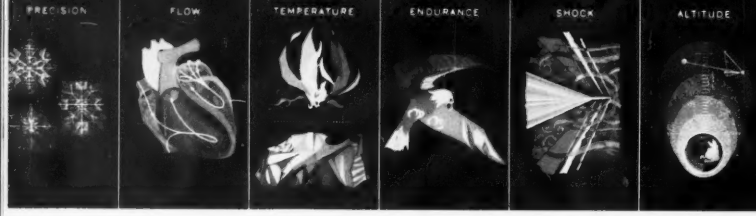

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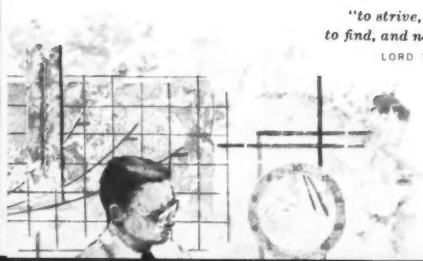
"to strive, to seek,
to find, and not to yield"
LORD TENNYSON



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COVER: *"Space Trajectories," another in the exciting series of photograms prepared especially for Astronautics by the talented team of Erich Locker and Gladys Washburn, keynotes the full-scale State-of-the-Art Report in this issue. Background photo of the Andromeda galaxy is used by courtesy of the Harvard College Observatory.*

Astronautics

NOVEMBER 1959

Year Three of the Space Age

History becomes more contemporary every day. In the 56th year of the Air Age, the 20th year of the Atomic Age, the 17th year of the Jet Age, we enter the third year of the Space Age.

Thus far, most of the Space Age milestones are marked by a Hammer and Sickle stamped over a faintly visible Swastika. October 4, 1957, was the date of the first milestone—a manmade satellite rocketing into orbit around the earth. In rapid succession came other milestones: The first satellite to carry a living creature; the first satellite to orbit the sun; the first hard landing on the moon; and, on the second anniversary of the birth of the Space Age, the first vehicle to circle the far side of the moon.

During these two years, 18 satellites have been launched into earth orbits and two into planetary orbits, while one vehicle has landed on the moon and another has circled behind it. In addition, other probes have flown far into space and fallen back into the earth's atmosphere.

Scientific progress, however, still depends on the roadbuilding between milestones. Data from numerous satellites have made possible the mapping of the Van Allen radiation layers. This knowledge has been published in accordance with the best traditions of objective science. What cosmic irony lies in the paradoxical secrecy of propaganda science with its proprietary presumptions!

Space sporting records have their place, but data and scientific records are even more important. It is fitting, therefore, that this Second Astronautics Annual should be devoted to a full-scale state-of-the-art report. This report represents the concerted efforts of the 22 ARS Technical Committees to disseminate as widely as possible complete information on scientific, technical, and engineering developments within their own areas of activity. As such, it is without question the most comprehensive report of this kind ever attempted, and one which only *Astronautics* could carry out.

In this, Year Three of the Space Age, nothing must hinder free scientific communication if the success of man's first flight into space is to be assured.

All previous milestones are but stepping stones toward this historic fulfillment.

John P. Stapp
President, AMERICAN ROCKET SOCIETY

X-15 shortly after launch. In the coming year, X-15 flight-test program should start to contribute research data up to its design Mach number of six.

The NASA program for 1960

Advanced testing of Mercury capsule and tracking and communications system, Vega and Centaur development programs, satellite experiments utilizing Juno II and Thor-Delta as launchers, and X-15 flight-tests highlight the nation's civilian spaceflight program in the year ahead

Homer J. Stewart joined NASA as director of the Office of Program Planning and Evaluation in October 1958. He was previously professor of aeronautics at CalTech and chief of JPL's Liquid Propulsion Systems Div. At NASA, Dr. Stewart is responsible for the planning of national programs in space technology and exploration both for the immediate and long-range future, as well as evaluation of progress in programs already underway. A native of Michigan, he received his B.S. in aeronautics from the Univ. of Minnesota in 1936, and earned his doctorate in aeronautics at CalTech in 1940. While at CalTech, he became interested in rocketry and was a member of the small group of CalTech scientists and engineers whose rocket experiments led to the formation of JPL.

By Homer J. Stewart

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, D.C.

THE FIRST YEAR of operation of the National Aeronautics and Space Administration was ended on Sept. 30, 1959. A great part of the effort expended during the year has been directed toward the organizational problems of bringing into existence a new agency and toward initiating the programs required, in the long run, to create a sound technology and an advanced capability for operating in the new environment beyond the earth's atmosphere. In addition to this type of problem, an active program of research, both within and outside the atmosphere, has been pursued.

The most dramatic portions of the research program are, of course, the flight-test experiments, and a goodly number of significant flight-tests were carried out during the year. Some of the most successful flight-tests during the year were the launching of Pioneer IV past the moon and on into a heliocentric orbit on March 3, 1959, the initial glide test of the X-15 on June 8, 1959, the launching of Explorer VI into a highly eccentric earth satellite orbit on Aug. 7, 1959, and the re-entry and recovery test of a full-scale Mercury capsule launched on Sept. 9, 1959 by the same model of the Atlas booster which will be used for later orbiting flights.

The NASA program for the second year of its activity, 1960, has been presented in considerable detail in the Congressional hearings for the fiscal year 1960 budget, and it is the purpose of this report to summarize the program. It is obviously impractical in a brief summary of this type to cover the complete details of the complex and comprehensive program involving all phases of aeronautical and

space research. Instead, program highlights, primarily those associated with flight-tests, will be noted as a measure of the over-all program.

The simplest and most direct measure of the over-all program is given by the budget. The NASA appropriation for fiscal 1960 and the 1959 supplementary appropriation are summarized in the table below right. The sum of these two items represents about a 50 per cent increase in over-all support over the 1959 appropriation.

Top Priority for Mercury

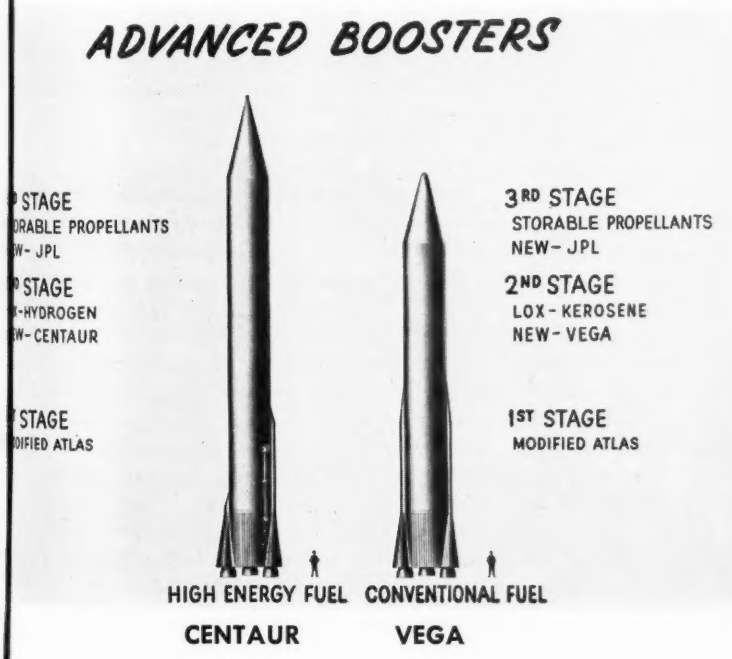
The highest-priority project in the current NASA program is Project Mercury, which is directed toward a demonstration of manned orbital flight. The last year has seen the completion of practically all phases of planning for the experiment, the initiation of contracts for the development and testing of the many pieces of specialized technical equipment needed, and the choice and initial training of the seven Astronauts who will carry out the flight-test assignment. Next year's highlights will include the production, deployment, and checkout of the complex tracking and communications system required for the experiment. The capsule will be carried into the advanced phases of testing for orbital flight qualification and the Astronauts will enter the most advanced phase of training with suborbital flight-tests using Redstone boosters.

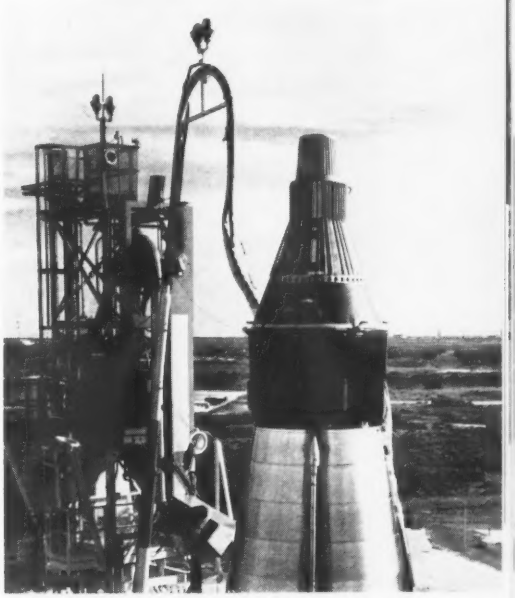
The next most important projects in the NASA program are the Vega and Centaur vehicle development projects, designed to provide a great increase in our capability to carry out both low-altitude orbital missions and deep-space missions of the lunar, 24-hr orbit, and planetary types. Vega is being developed along conventional lines in order to obtain this advanced capability in the shortest possible time, while its companion project, Centaur, is directed toward the practical engineering solution of the problems of using a high-energy hydrogen-oxygen propulsion system, and should provide, over a longer time scale, a still greater increase in capability. Neither of these two important projects is expected to reach the flight-test phase during the next year. However, both should proceed well along in the preflight de- (CONTINUED ON PAGE 126)

NASA 1959 Supplemental and 1960 Appropriations

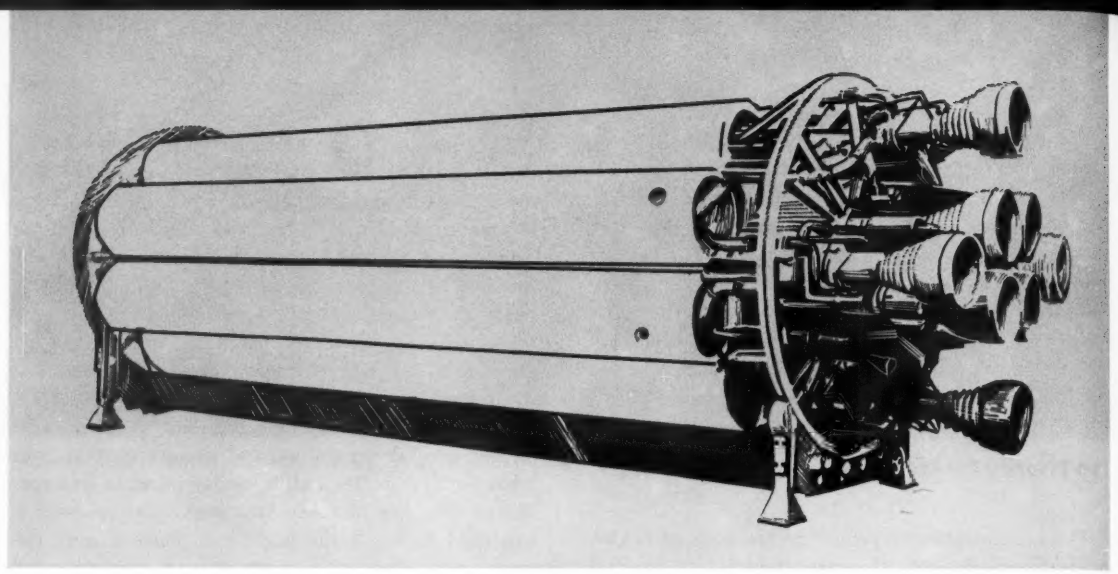
	1959 Supplemental	1960 Regular
Salaries & Expenses	$ 3,186,300*	$ 91,400,000
Research & Development	16,657,000	318,675,000
Construction & Equipment	21,825,000	52,000,000
TOTAL	41,668,300	462,075,000

* Pay Act Supplemental, expended in fiscal year 1959.





Full-scale Mercury capsule ready for launch. Mercury project has highest priority among current NASA programs.



Saturn booster—75 ft high, 22 ft in diam and generating 1.5 million lb of thrust—will be static-tested during 1960.

The military space program for 1960

Advanced astronautical research and space technology development in Department of Defense is aimed at military missions and objectives

George P. Sutton, 1958 ARS president, has devoted his career to rocket and missile research and development programs. After his education at California Institute of Technology, where he taught courses in mechanical and aeronautical engineering, he joined Rocketdyne. As manager of advanced design there, he had an integral part in many of our large missile projects. Last year, as Hunsaker Professor of Aeronautical Engineering at MIT, he lectured on rocket propulsion. In his present position as chief scientist of ARPA, he manages advanced research and development programs in space technology for the Department of Defense.

By George P. Sutton

ADVANCED RESEARCH PROJECTS AGENCY, DEPARTMENT OF DEFENSE, WASHINGTON, D.C.

SINCE the dawn of history, man has explored the environment which surrounds him and has exploited his new knowledge to make himself more secure. To the casual headline reader, it would appear that, as a nation, we seem to have leaped into an exotic Space Age. Contrary to this impression however, the Department of Defense has for many years been undertaking an initial examination of the space environment and has available important resources of knowledge and hardware with which to develop the defensive and offensive capabilities of operation in this new human dimension.

We are extremely fortunate that our military missile capability is readily applicable and convertible to astronautical projects. In fact, most of our rapid progress in space technology to date has been possible because we have been able to adapt existing military missile technology to spaceflight, such as using present rocket engines, large ballistic missile boosters, modified armament rockets, missile guidance systems, present launching ranges and techniques, tracking facilities, missile assembly plants, and available trained technical personnel. Without missile technology, there would be no stepping stones for mankind to venture into space, and without the pioneering accomplished by the military, there would be no missile technology.

With the advent of the Space Age, heralded by the appearance of

Sputnik and subsequent developments in missile hardware, it soon became apparent that if the U.S. wanted maximum progress without duplicating the enormous costs involved, it would have to concentrate its R&D efforts in one agency for over-all management from a military point of view. This led to the creation of the Advanced Research Projects Agency in February 1958, under Public Law 85-325, 85th Congress. Key dates in ARPA's work are shown in the table on this page. Although the first program assigned to ARPA was military space technology (which today is still the largest ARPA activity), research and development effort in other important areas such as ballistic missile defense, high-energy solid propellants, and basic materials research is also being managed and monitored by ARPA today. While these areas are growing in importance, they are not detailed in this paper.

ARPA Manages Projects for DOD

ARPA controls and manages, for the Department of Defense, a series of projects which are described in this article. In addition, the Air Force, Army, and Navy carry out several projects (such as system feasibility studies, X-15, or DynaSoar) related or directly applicable to spaceflight which are coordinated within DOD. (CONTINUED ON PAGE 110)

Typical DOD Missile Programs Applicable to Space Technology

Project	Initiation Date (Approx)	Original Purpose	Space Application
V-2 Wac	1946	Familiarization Test Firings	Forerunners of Later Systems
Bumper-Wac	1949	Hi-altitude Research	Stage Separation
Redstone (Forerunner of Jupiter) (Army)	1950	Ballistic Missile	Booster for Explorer and 1st stage for Jupiter-C
Jupiter (Army)	1953	Ballistic Missile	Satellite Booster
Atlas (Air Force)	1954	Ballistic Missile	Booster for Midas, Mercury, Score, Vega, Centaur, Samos
Thor (Air Force)	1955	Ballistic Missile	Booster for Discoverer, Able Courier, Transit
Vanguard (Navy)	1955	Research Satellite	Components used in Able, Vega
117-L (Air Force)	1956	Reconnaissance Satellite	Split into three: Samos, Discoverer, Midas
Rover (AEC-AF)	1956	Engine Research	Large Space Payloads
Missile Ranges			
Army-WSMR (WSPG)	1945	Launch	Launch
Navy-PMR (Pt. Mugu)	1946	& Track	& Track
AF-AMR (Patrick)	1947	Missiles	Space Vehicles

ARPA Milestones in Space Technology

Date	Event
February 1958	ARPA created under Public Law 85-325, 85th Congress, and DOD Directive 5105.15
	Cognizance of 117-L Program Assigned from AFBMD to ARPA
March 1958	First ARPA Orders Issued To Army for Lunar Probes To Air Force for Lunar Probes To Navy for Lunar Probe Tracking
April 1958	Project Argus, Nuclear Detonations Outside of Earth's Atmosphere
June 1958	Tracking Fence
	117-L Program Split into Samos, Discoverer, and Midas
August 1958	Project Score (Talking Atlas)
	Centaur (High-Energy Booster)
	Saturn (1.5-Million-Pound-Thrust Cluster)
September 1958	Solid-Propellant Program
	Navigation Satellite
October 1958	Communications Satellite
	Transfer of ARPA Orders 1, 2, and 3 to NASA (Lunar Probes)
November 1958	Midas (Missile Defense Alarm System)
December 1958	Discoverer
January 1959	Active Repeater Communications Satellite
	Advanced Radar Research
February 1959	First Discoverer Launch Test
April 1959	Space Power Research (Solar and Nuclear)
	DynaSoar (Orbital Weapons Systems Study)
July 1959	Select Titan as Booster for Second Stage on Saturn
	Transfer Centaur to NASA
	Transfer Meteorology Satellite to NASA
	MRS-V (Maneuverable, Recoverable Space Vehicle)

Galileo Kepler Newton

This article, based on an address delivered by Col. Stapp, ARS president this year, at the Society's 1959 Semi-Annual Meeting in San Diego, June 8–12, serves as a fitting introduction to the 22-state-of-the-art articles which follow, since it is, in essence, an examination of the state of Man himself as he enters the Space Age.

Man's mission in space

All the qualities which distinguish Man from other forms of life on this planet will be called into play as he rises to a supreme, self-made challenge greater than any ever faced by the human race

By Col. John P. Stapp

AF AERO MEDICAL LABORATORY, WADC, WRIGHT-PATTERSON AFB, OHIO

John Paul Stapp holds B.A. and M.A. degrees (in zoology and chemistry) from Baylor Univ., a Ph.D. degree in biophysics from the Univ. of Texas (1940), and an M.D. degree from the Univ. of Minnesota (1944). During his 15-year service career, Col. Stapp has served as general duty medical officer, industrial medical officer, flight surgeon, and research specialist in aviation and space medicine. Perhaps best known for his 29 rocket sled deceleration and windblast experiments, which won him the title of "fastest man on earth," he founded and organized two laboratories, the Aeromedical facility of Edwards AFB and the Aero Medical Field Laboratory of Holloman AFB, for the Air Force, and is now chief of the AF Aero Medical Laboratory, Wright Air Development Center.

CIVILIZATION, in essence, is survival instinct transfigured into the hope of immortality, and passion sublimated into compassion.

Motivated first by religion, civilization found a contemplative evolvement in Asia, with emphasis on states of being. Centered on self-development, it flowered in artistic and poetic expression, mathematics, and mysticism. In the West, religion established socially directed, gregarious patterns, with emphasis on good actions. The justification of the individual in terms of his contribution to the welfare of the group motivated civilization in the West along lines of dynamic solidarity.

Logically, the progressive materialism of modern experimental science evolved from and contributed to Western philosophy. The atomism of the Greeks contrasts sharply with the Nirvana of the Hindus. When East meets West, the Mandarin says, "May your shadow never grow less," and the Yankee replies, "What can I do for you?" The Westerner earns a heavenly reward by good works; the Easterner gains merit toward reincarnation in a better state of being.

In modern experimental science, truth is arrived at by arduous, disciplined skepticism. It refuses speculation except in the evaluation of experimental approaches to the unknown; it accepts an endless state of flux demanded by the perpetual revision of principles through the discovery of new facts and the evolution of new methods of analysis. It is dynamic in the same sense that reaction propulsion expands and accelerates. To minds that yearn for vague, comforting generalizations and banal, abstract finalties, modern experimental science is deplorable and distressing.

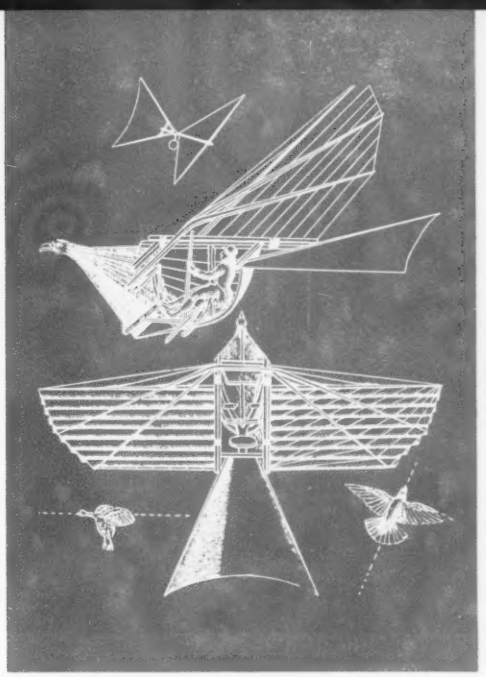
Inexorably, the scientific method seeks universal laws by exploring

the universe for them. Man can look both ways from the middle of the dimensional range accessible to him. Microscopically, he looks toward the electron; telescopically, toward the outer galaxies of his universe. Basic consistency with the nature of the scientific method requires exploration of all phenomena in all attainable dimensions. The quest for the unknown is no less compelling in our solar system and beyond than in subatomic particle phenomena. Indeed, they are interrelated.

In the past, great astronomers, with unlimited intellectual audacity and limited telescopes, did what they could to explore the universe which we are privileged to penetrate with our missiles. They left us a challenge either to explore the extraterrestrial universe by every means we can develop or to resign ourselves to willful ignorance, defectors to the consistency of the scientific method and no better than speculative philosophers. We cannot fall short of seeking the whole truth within our grasp concerning our universe. There is no doubt that men will embark on journeys of exploration beyond the aerodynamic atmosphere, within and beyond the solar system, and as far into outer space as the span of human life and available means of propulsion and guidance will allow.

The effort must be dedicated to gaining knowledge and mastery of our universe, with no delusions as to material gain and no reservations about material cost. Dismal pages of history recall crusades and wars that left us no better legacy than the record of ruined cities and overthrown civilizations. As the challenges of their era, offering the only hope of human progress, these wars and crusades were bravely undertaken even though they brought tragic consequences in their wake.

In this frame of reference, our generation is on the launching pad for the greatest era of scientific exploration that man can hope to undertake. It is a crusade for knowledge of the universe that must ineffably enlarge the domain of human civilization to universal dimensions. In this light, motives of material gain become trivial and adventurous bravado absurd.



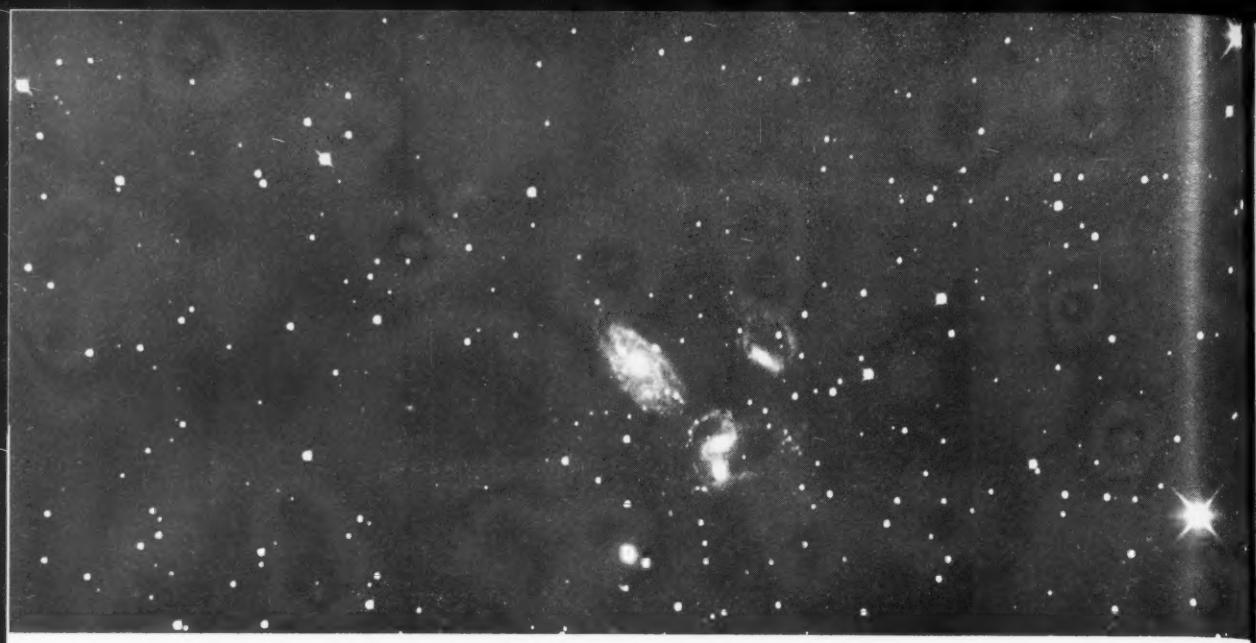
Challenges All Mankind

Human pride in priorities of discovery should not corrupt this great effort with paltry competition. It is a challenge to the world of science, recognized in the organization of the International Geophysical Year; it is an area of human endeavor above and beyond the polemics of nationalism. If ideals are admissible to science, here they will set standards.

Granting him ample courage to undertake spaceflight, what of man's capabilities to endure the known and partly known ordeals of the journey and to contribute more than his mere survival in the experiment?

Even on his native earth, a narrow range of environmental factors determines the distribution of human populations. One of the least likely causes of international tension would be a boundary dispute in the Antarctic polar continent; lack of water in the Sahara limits the population to scattered tribes of nomads; the overabundance of water in tropical rain forests produces green barriers against penetration; mountain heights above 16,000 ft are only briefly attained by hardy sportsmen and scientists.

To travel in space, man must enclose all his living requirements for the duration of the flight within the spaceship. (CONTINUED ON PAGE 130)



State of the Art, 1959

Astrodynamics

By Samuel Herrick and Robert M. L. Baker Jr.

UNIV. OF CALIFORNIA AT LOS ANGELES AND AERONUTRONICS, RESPECTIVELY

For the ARS Astrodynamics Committee

AN ACCELERATING INTEREST in the field of astrodynamics is evidenced by the number of papers connected with it that have been presented recently at national and international meetings, including approximately 27 at the 10th International Astronautical Congress in London and 13 to 16 at the May and November meetings of ARS (San Diego and Washington).

Progress in the determination of gravitational and other environmental constants has been notable this year, but the theoretical side of astrodynamics is still somewhat hampered by the lack of preparation of many of the contributors to the field. The urge to embark hastily upon analysis and writing without understanding either the historical or even the contemporary advances in the field is still unduly crowding the technical journals. On the other hand, thoughtful application of astrodynamical techniques to range systems (e.g., the NASA Project Mercury range and the satellite filter center of the U.S. Air Force) is making substantial contributions to efficient design and will pay off in dollars and cents in the long run.

As predicted in our survey, "Recent Advances in Astrodynamics," in the Oct. 1958 *Jet Propulsion* (now *ARS Journal*), to which the present article and its bibliography are in a sense a sequel, the emphasis of a considerable part of the effort in astrodynamics has been in precision orbits. Here, studies show wide variety and scope, justifying the definition of astrodynamics as including those portions of celestial mechanics, geodesy, aerodynamics, exterior ballistics, electromagnetic theory, geophysics, astrophysics, and observation theory that bear on the trajectories of natural and manmade planets, satellites, comets, meteorites, and other objects above the denser portions of the earth's atmosphere. These areas are not only of concern to precision orbit work, but also should be considered with a spirit of care and patience in all astrodynamical problems.

Earth's Influence on Trajectories

Determinations of the earth's gravitational field and of the density of the atmosphere and its affect upon trajectories have deservedly received a considerable share of attention in recent months. The coefficient, J, of the second harmonic in the earth's potential has been re- (CONTINUED ON PAGE 180)

State of the Art, 1959

Communications

By Max A. Lowy

CHIEF SYSTEMS ENGINEER,

DATA CONTROL SYSTEMS, DANBURY, CONN.

For the ARS Communications Committee

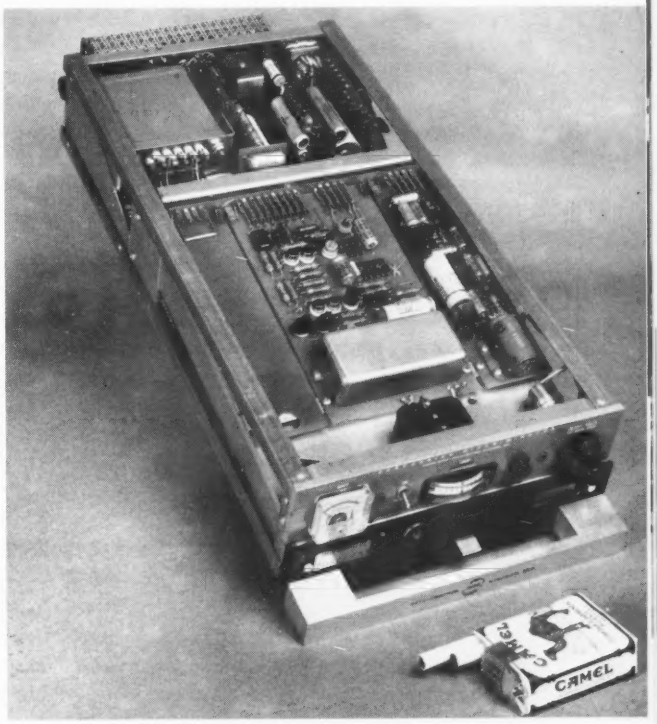
IN GENERAL, the greatest step forward in the past year has been connected with the application of semiconductor devices. The initial equipment requirement placed on the industry by the leap into space, via satellites and probes, has been reflected back into equipment now being utilized or planned for long-range missiles such as the Minuteman and the Polaris, and is presently making its effect felt on the design of new ground equipment. Although transistorization of airborne components for use in missiles dates back to 1951 and 1952, it was not until recently that serious attempts were made to transistorize large portions of the electronic systems connected with long-range missiles and space vehicles. Some background material was available from telemetering and guidance systems utilized in such early missiles as the Corporal. However, these systems were simple compared with today's. The designer of electronic equipment was forced to consider the problem of weight, power, and volume suitable for spaceprobe payloads. The serious reduction in size and weight required for the first Pioneer probe obsoleted existing equipment. The obvious answer lay in the design of transistorized equipment.[1]

First Used in Satellites

Like all other new techniques, transistorized circuitry required support before its adoption was made possible. The initial requirements of satellites and space probes demanded immediate development of lightweight, reliable telemetry and communications equipment to operate over long periods of time from light, low-power battery packs. In practically all cases, the development of these transistorized systems was accomplished by the organizations who built and fired the satellites and space probes. However, acceptance of these systems and their surprising performance gave enough information to the field to increase the desire of the large missile users and experimenters for transistorized equipment. This acceptance cleared the way for the development of such equipment by commercial organizations, who could then in turn offer this equipment for sale as standard commercial items for use in large or small missiles or space vehicles.

The past year has seen a tremendous growth within the industry of proprietary items of a transistorized nature. For the telemetry field, this has included the development of a number of completely transistorized voltage-controlled oscillators, resistance-controlled oscillators, DC amplifiers, AC amplifiers, voltage regulators, and a very wide variety of voltage converters. From the RF point of the communications link, there are several transmitters operating within the telemetry band and yielding approximately 2 watts that are at least partially transistorized. The state of the art has not allowed full transistorization of 2-watt transmitters within the 220-mc band.

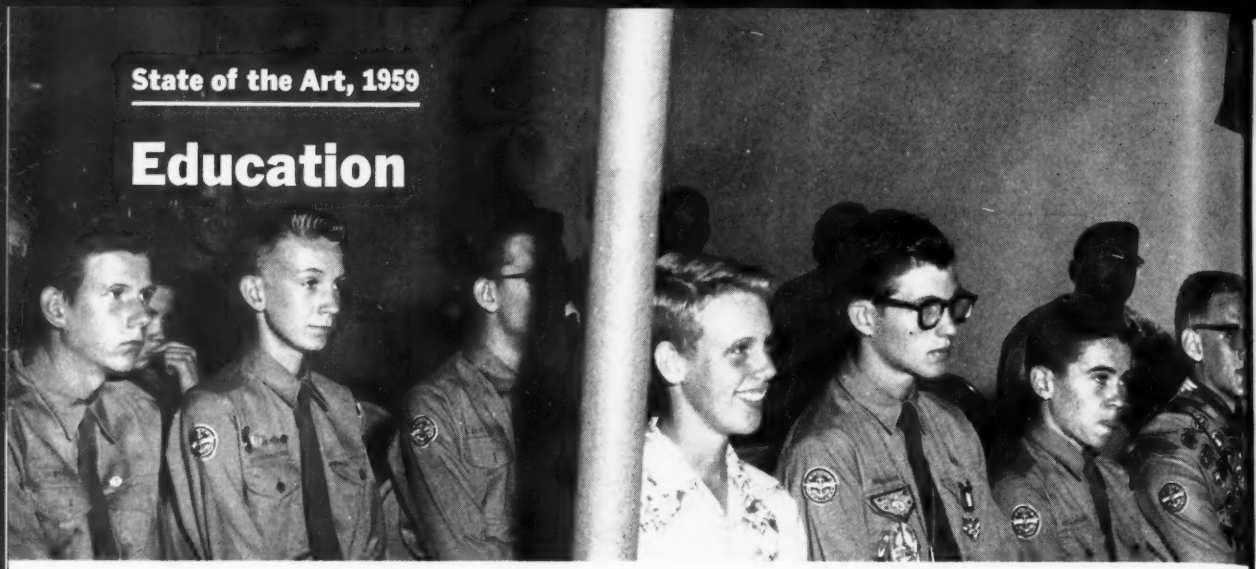
However, the Air Force's first moonprobe project, Able-1, did contain a completely transistorized transmitter operating at approximately 105 mc and yielding a power output of close to $^1/_2$ watt.[2] Strangely enough, the resulting equipment has not only proved to be more reliable than its old vacuum-tube counterpart, but in practically (CONTINUED ON PAGE 171)



This all-solid-state-device miniature phase-lock-loop discriminator for use with FM/FM telemetering systems is typical of the broad practical application of semiconductor devices to complex communication systems in the past year.

State of the Art, 1959

Education



By Paul E. Sandorff

ASSOCIATE PROFESSOR, AERONAUTICS AND ASTRONAUTICS DEPT., MIT, CAMBRIDGE, MASS.

For the ARS Education Committee

A RECENT ARS survey indicated that considerable progress has already been made by many large universities in incorporating astronautics topics into their curricula.[1] The number of accredited engineering colleges in the U.S. is about 200; more than half now offer courses of instruction and provide research opportunity in some field of engineering or science directly related to the astronautics profession.

However, this situation may be misleading for the prospective university student who hopes to qualify as an astronautical engineer or scientist in four or five years. First of all, proficiency in astronautics requires all the technical background of one of the established fields of science or engineering, plus competence in several other disciplines not formerly found in these already crowded curricula. Secondly, a review of this year's bulletins reveals that in only a few universities do the newly introduced astronautics courses form part of a cohesive academic program.

One Approach to the Problem

One method of establishing a coordinated program in astronautics is to consider systems engineering of an astronautical vehicle as possible ultimate objective, and to establish the necessary background in all relevant fields as preparation for an exercise in the analysis and synthesis of vehicle design. This approach is strongly evident in several engineering schools; and to the graduate of such a program, the degree of Bachelor of Science in astronautics would be truly significant. Successful Master's and Doctor's programs in astronautics may also be based on the flight-vehicle concept in education. This has been achieved in the special military officers program in astronautics at MIT that has been attended by selected Air Force and Naval personnel.[2] However, it seems clear that a broad cohesive academic program in astronautics is still relatively rare, and that in the near future, as in the past, the majority of astronautical engineers and scientists will be recruited from conventional academic circles.

Most prospective astronauts will wisely seek further postgraduate education in a specialty. Partly in response to urgent and growing need, and largely as a result of the endorsement of university research programs by governmental agencies in recent years, our institutions have created strong centers of study and research where advanced training in astronautics specialties is possible to a depth and sophistication unique in the history of education. A postgraduate program at such a center may usually be based on undergraduate work at any of the better engineering and science schools. At the risk of censure for unintentional omission, a table on page 132 is offered as a partial list of the centers for specialized study and research which have received widespread recognition.

That an educational problem exists for the youthful astronaut is made (CONTINUED ON PAGE 132)

State of the Art, 1959

Guidance and navigation

By Lawrence S. Brown

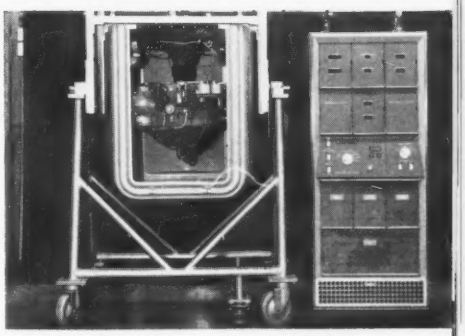
AVIONICS SUBCONTRACT ADMINISTRATOR, GRUMMAN AIRCRAFT ENGINEERING CORP., LONG ISLAND, N.Y.

For the ARS Guidance and Navigation Committee

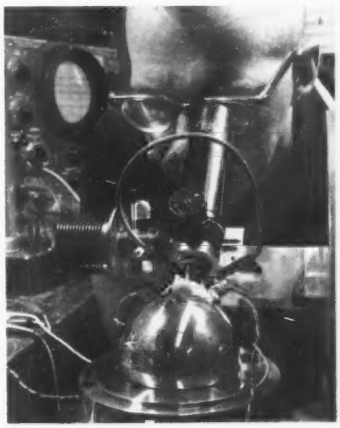
AS WE VENTURE to make the annual assessment of the state of the art in the field of guidance and navigation, it is again evident that haste is being made slowly. The inventions and improvements being made in 1959 would have been individual landmarks 20 years ago, but today they constitute relatively small ramp-function increases to the vast cumulative technology.

Only moderate progress has been evidenced in guidance systems for second- and third-generation long-range ballistic missiles.[1–5] The trend to all-inertial systems has continued for "operational" and developmental missiles. The advance of the inertial art—using presently available components—is reaching the point of diminishing returns, but significant advances appear theoretically possible from work being done on radically new gyros.[6]

One of these is the electrostatic gyro with a spherical rotor suspended between three pairs of support electrodes, with other electrodes for capacitance pickoffs. A more exotic type being actively researched is the particle gyro, based on angular and magnetic moments of protons and electrons. A "rate-of-turn" version is based on magnetic resonance detection of frequency changes caused by imposed angular momentum vectors. A "position" type, operating at superconductive cryogenic levels, employs the rigidity in space of molecular spin in liquids and gases.



State of the art sees compact ballistic missile guidance systems, like this Polaris autonavigator (above), become reality, and researchers turning to new approaches, such as the electrostatic-suspension gyro, to gain new levels of accuracy. Polaris autonavigator contains inertial platform, gyros, and velocity meters in binnacle (uncovered) at left and all other electronic equipment in console at right. Below, Minneapolis-Honeywell engineer examines beryllium sphere with tolerances of less than 15 millionths of an inch that will form the rotor of the highly accurate electrostatic-suspension gyro being studied by M-H.



Difficulties Involved Are Imposing

In one type being worked on, liquid helium is quantized by a magnetic field which aligns and fixes the spin axes of molecules possessing magnetic or electric dipole moments. After the field is removed, sensing is performed by detection of the angle of intersection between polarized ultraviolet light and the space-fixed spin system. The difficulties involved in these techniques are imposing, to put it mildly. The radiations resulting from acceleration of the particles are minuscule and subject to disturbance on nuclear and thermodynamic levels, and detection (by the magnetic resonance method) of induced output voltages is in the micro-microvolt range.

Without a doubt, the greatest strides in the past year have been made in the further development and application of miniaturized digital computing systems.[7] The pioneering (and proving) of these ultrasophisticated devices, acting as central data processors, is being accomplished in heavily "avionic" aircraft well along in development. They serve as the focal point among a variety of sensors, ground links, and control systems. Some of the functions simultaneously performed are multiple target tracking, identification, and evaluation; multiple interceptor direction; (CONTINUED ON PAGE 150)

This full-body restraint system for spacecraft, designed and modeled by Gary Graham of Boeing, reflects the new closeness of human factors and engineering science.

State of the Art, 1959

Human factors and bio-astronautics

By Lt. Col. Stanley C. White (USAF-MC)

RESIDENT FLIGHT SURGEON, SPACE TASK GROUP, NASA LANGLEY FIELD, VA.

For the ARS Human Factors and Bio-Astronautics Committee

SINCE the first post-Sputnik frenzy, human factors and bio-astronautics activities in this country have developed into a logical stepwise program leading to spaceflight. As part of this program, the ARS Human Factors and Bio-Astronautics Committee enlarged its coverage to encompass all phases of manned rocket and space-vehicle operation. The programs sponsored by the Committee during the year have tried to reflect this widened mission, covering such diverse areas as selection of astronauts, design of crew-training and holding facilities, and newly defined human tolerances to spaceflight conditions.

The human factors area least publicized, but greatly developed, last year, was that of crewman support for a space mission. The job the crewman will do and the methods available to permit him to do his job efficiently have received great emphasis. The Committee is currently studying suggestions for sessions on this subject for the near future. These sessions would permit the formal presentation of progress in this area at a centralized location, and make information available to everyone directly concerned with human factors and bio-astronautics.

During 1959, there has been a transition in the space-exploration planner's thinking. The planner has moved from discussing whether man *should* be sent into space, and of what value he would be in a space vehicle, to discussions of how man could be used as a full contributor and participant in space-vehicle operations. As a case in point, NASA established Project Mercury under its top priority to demonstrate development and flight of a manned space vehicle.

Need for Data Stressed

To support this area, the Committee has presented, in formal sessions, the environmental-system approaches and the need for data which will permit early flights. Many members of the Committee and many ARS members concerned with human factors are devoting a great part of their active careers to bringing such flights from the idea stage to hardware.

Significant programs which characterize progress in this area are the X-15; Project Mercury; Project DynaSoar; bio-pack flights; studies in weightlessness, transverse acceleration, and impact acceleration; radiation satellite studies; psychological and psychiatric studies on crew (CONTINUED ON PAGE 166)

State of the Art, 1959

Hypersonics

By William H. Dorrance

SENIOR STAFF SCIENTIST, CONVAIR

SCIENTIFIC LABORATORY, SAN DIEGO, CALIF.

For the ARS Hypersonics Committee

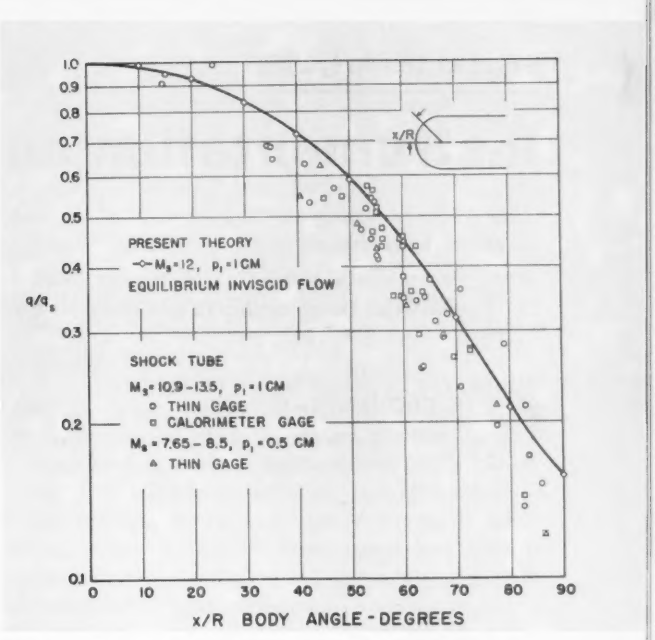
THE YEARS 1958 and 1959 are significant in the field of hypersonics as a period of consolidation of effort and recognition of this field as an important, distinct branch of gas dynamics. This recognition is exemplified by an increasing awareness of the unique characteristics of hypersonic gas dynamics, by the formation of the ARS Hypersonics Committee, and by the appearance of the initial textbook in this field.

Perhaps it is in order to establish a frame of reference for a state-of-the-art review by quoting the description of the field of hypersonics which has been agreed upon by the members of the ARS Hypersonics Committee.

> "Hypersonics is the field of science concerned with phenomena associated with the flight of objects at a high velocity through an atmosphere. The atmosphere can be that of earth or other planets, or liquids or gases chosen for laboratory purposes. Viscous and nonviscous, continuum and noncontinuum, ionized and nonionized gas flows might reasonably be included under certain circumstances. The interplay of chemical kinetics with gas dynamics frequently characterizes hypersonic gas flows. A distinguishing feature of hypersonic gas dynamics is that of high flight Mach number."

It is with the above definition in mind that we look at advances in the past year.

But first, several recent review articles have appeared on various aspects of hypersonics which are recommended to the interested reader. Allen[1] has summarized in detail the classical aerodynamic problems involved in re-entry and hypersonic flight. Real gas effects and the effects of dissociation and recombination on heat transfer were discussed by Griffith[2] and Rosner,[3] respectively. Sears[4] reviewed the prospects for magnetohydrodynamics. The subjects of these review articles will not be dwelt upon here in great detail.



Heat-transfer theory and measurements compared for hemisphere-cylinder using theory of Kemp, Rose, and Detra (see Reference 14).

The cool mercury plasma tunnel, shown in action at Mach 3, with flow excited by radio-frequency field, was designed by Eckert to study continuous plasma flows (see Reference 45).

Hypersonic flight speeds engender high kinetic energy and thus high enthalpy levels in the compressed or retarded air in the boundary layer and shock layer ensheathing a hypersonic body. These high enthalpy levels in turn are characterized by chemical reactions taking place in the air mixture. Recent theories for the inviscid and viscid flow around hypersonic bodies (CONTINUED ON PAGE 78)

State of the Art, 1959

Instrumentation and controls

By Herbert Friedman

HEAD, ATMOSPHERES AND ASTROPHYSICS DIV., U.S. NAVAL RESEARCH LABORATORY, WASHINGTON, D.C.

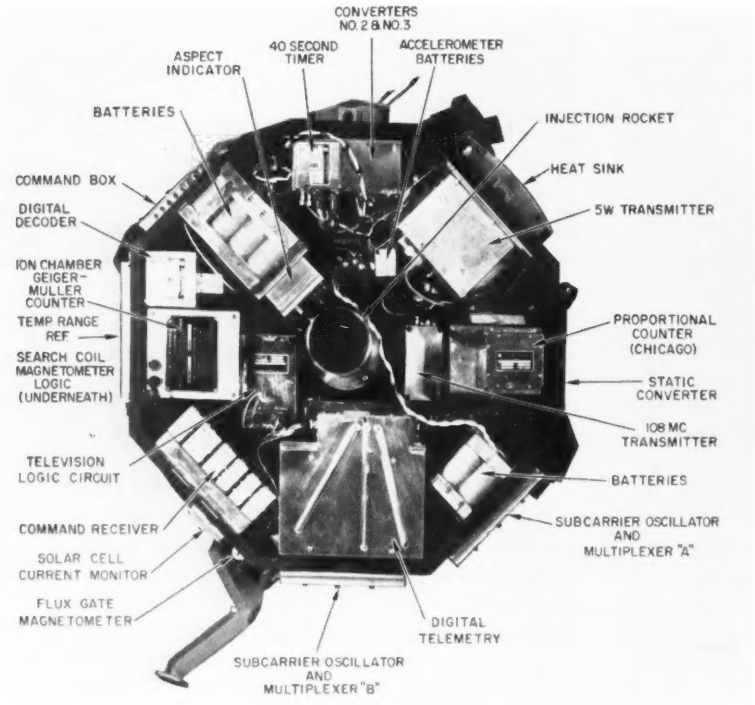
For the ARS Instrumentation and Controls Committee

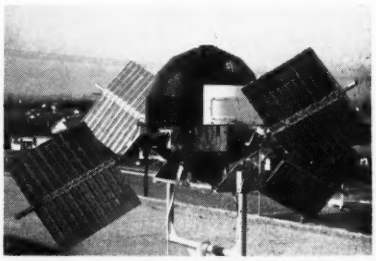
IN THE FIELD of instrumentation we are concerned with apparatus and techniques applied to the detection, measurement, evaluation, transformation, and display of information, and the conversion of information to control operations. Rocket engineering and space research have generated such unique requirements for performance testing, controls, and payloads that instrumentation has come to represent one of the most important aspects of Space-Age technology.

The instrumentation of rockets, satellites, and probes for research in the upper atmosphere and interplanetary space presents a great challenge to developers of payload instrumentation. Included in this category are photoelectric sensors, particle detectors, image converters, spectroscopic devices, magnetometers, atomic clocks, meteorite detectors, pointing controls, stable platforms, and telescopes. Several outstanding achievements within the past year are worth noting.

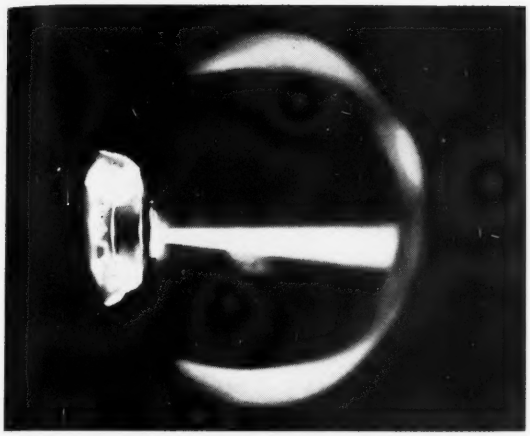
Work Progressing on Atomic Clocks

Among the most sophisticated instruments now under development for satellite experiments are atomic clocks and magnetometers. The possibility exists of testing the general theory of relativity by comparison of the gravitational effect on the rate of a clock in a satellite relative to a clock on the ground. In a satellite with apogee at 25,000 km, the average shift should (CONTINUED ON PAGE 114)





Even the sophisticated Explorer VI, shown (left) with instruments exposed, now rides in the wake of the instrumentation art.



State of the Art, 1959

Ion propulsion

By Ernst Stuhlinger and Robert N. Seitz
RESEARCH PROJECTS LABORATORY,
ARMY BALLISTIC MISSILE AGENCY, HUNTSVILLE, ALA.
For the ARS Ion and Plasma Propulsion Comm.

RAPID PROGRESS made in ion-rocket development programs in the last few months justifies some optimism regarding prospects for a small but useful ion motor within the next few years. The Goodrich-High Voltage Astronautics Inc. has reported 30-milliamp (ma) currents of mercury ions at a specific impulse of 7600 sec produced with a von Ardenne-type arc source. The measured thrust is 400 dynes, and the ratio of beam kinetic power to total electrical power input is greater than 50 per cent. General Electric has reported total beam currents of as much as 75 ma and a power conversion efficiency of about 15 per cent with a surface ionization source. Electro-Optical Systems Inc. has succeeded in achieving very low electrode interception losses and current densities of 14 ma/cm^2, also with a surface-ionization source. Other equally advanced work is taking place at Thompson Ramo-Wooldridge, Rocketdyne, NASA's Lewis Research Center, Wright Air Development Center, Curtiss-Wright, Aerojet-General, Convair (Ft. Worth), Marquardt, Pratt & Whitney, Hughes Aircraft, and other organizations throughout the country.

This may be contrasted with the situation which prevailed six months ago. At that time, the reported power conversion efficiencies were 2 to 3 per cent, with 20 per cent or more of the accelerated ions being intercepted by the acceleration electrodes. Also, no deliberate ion-beam neutralization or direct-thrust measurements had been accomplished.

What are some of the remaining problems pertinent to ion-rocket-motor development? It is convenient to divide the task of ion-rocket-motor development into three main problem areas. These are the development of a suitable ion source, a low-interception accelerator, and a low-loss ion-beam-neutralization system.

An ion source for a propulsion device must satisfy certain stringent requirements. Its weight should be small in comparison with the weight of the ion-rocket's electrical powerplant. It should convert as large a fraction as possible of the available electrical energy into kinetic energy of the ions in order to minimize the weight of the required electrical generation equipment. It must convert nearly 100 per cent of the neutral propellant atoms into ions. Furthermore, because of the low accelerations imposed upon ionically propelled vehicles by the power-to-weight ratios of their power-generation equipment, the ion source must have a long and reliable lifetime (preferably a few years) in order to permit the attainment of large vehicle velocities.

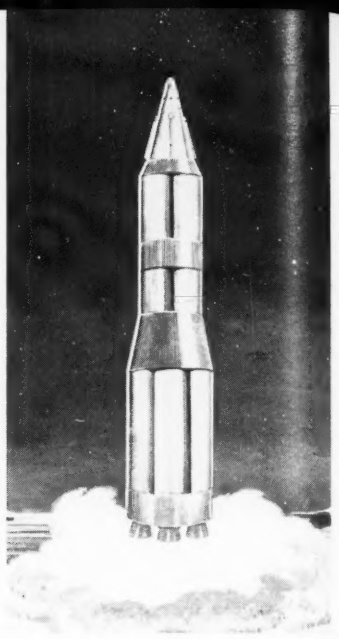
One type of ion source which may fulfill these strenuous requirements is the "duoplasmatron" arc source originally developed by M. von Ardenne. This device, which utilizes a magnetic field to constrict the plasma, promises high power and ionization efficiencies.

Another Promising Ion Source

Another promising type of source is based upon the catalytic ionization of alkali metal vapor by hot platinum or tungsten surfaces. This process occurs because the work function of tungsten is lower than the ionization potential of some of the alkali metals, i.e., the level of the "Fermi sea" in the tungsten is lower than the energy level of the valence electron in an adsorbed cesium or rubidium atom. The ratio of ions evaporating from a hot tungsten catalyst to neutrals striking the catalyst can be nearly unity. A graphical plot of the ion-to-incident-particle ratio is shown on page 98. These curves illustrate an important feature. It will be noticed that each of the ionization curves falls off sharply below a certain critical temperature which depends upon the current density drawn from the source. This occurs when the incoming cesium flow rate exceeds the evaporation rate, allowing a layer of cesium to build up on the catalytic surface. This lowers the catalyst work function, and thereby lowers the ion/atom ratio.

Since the evaporation (CONTINUED ON PAGE 94)

What reliability will the liquid rocket engines which will power gigantic vehicles like NASA's Nova achieve?



State of the Art, 1959

Liquid rockets

By Y. C. Lee

MANAGER, SPACE TECHNOLOGY DIVISION,

AEROJET-GENERAL CORP., AZUSA, CALIF.

For the ARS Liquid Rocket Committee

BY AND LARGE, progress in liquid rocket technology to date has not been extensive or spectacular, and programs have not been overly imaginative. Their initiation has been dictated primarily by immediate considerations for military requirements and/or space exploration.

Nevertheless, some progress has been made during 1959. From the standpoint of size, or more appropriately thrust scale, development of a 1 to $1^1/_2$ million-lb-thrust rocket has been initiated. It uses the well-established propellant combination of lox and RP-1. Such a program logically should be extended to the use of high-energy combinations such as lox and liquid hydrogen. In this regard, the Centaur program, involving development of a relatively small thrust lox and liquid-hydrogen rocket, has been initiated and represents a step in the right direction.

Obviously, the next step would be the development of a much larger thrust rocket, say on the order of 10 to 20 million lb of thrust. It is not difficult to predict that there will exist requirements for a 50 to 100 million-lb liquid rocket engine, if one is serious about space exploration. A simple calculation will show that, with a launch weight to payload ratio of 500, in order to put a 200,000-lb payload in space for lunar missions, the booster thrust requirement will be on the order of 100 million lb. For engines of the 100 million-lb-thrust class, the question of single engine versus a clustered configuration is one that can be answered only by detailed engineering analysis, design, and test.

Although the progress mentioned above has been made, it must be pointed out that basically speaking these programs have depended and drawn upon technology that has been in existence for the past 10 to 15 years. As an example, the feasibility of using lox and liquid-hydrogen propellants was demonstrated in 1949, while lox and RP-1 was investigated prior to 1949. The combustion problem in large rockets is resolved largely by empirical processes at considerable cost.

In view of these experiences, the logical question is what future course of action should be taken to replenish the store of technology for future use. The author would venture to suggest that the most important technological areas are (1) reliability and (2) propellant technology.

Little Reliability Data

Any discussion of reliability is handicapped by the relatively scant data available on which to base a valid estimate. The reliability of an engine is the reliability of each component raised to a power corresponding to the number of such components. The approach to improved reliability is therefore obvious. One is to decrease the number of components, and the other to improve individual component reliability.

It is pertinent to indicate here that control components contribute largely to reliability statistics. Thrust chamber valves, gas generator valves, turbopump control components, ignition and starting system components, electrical components, and sequencing units, just to name a few, all require extensive bench testing, environmental testing, and other types of tests to determine performance and reliability. In other words, in the course of engine development, special emphasis should be given to component testing before (CONTINUED ON PAGE 148)

State of the Art, 1959

Logistics and operations

By Robert B. Rypinski

CHIEF ENGINEER, FIELD SUPPORT BRANCH, MISSILE DIV., CHRYSLER CORP., DETROIT, MICH.

For the ARS Logistics and Operations Committee

IT APPEARS FITTING to begin this first annual review with the report of the establishment, by ARS, of the Logistics and Operations Committee. The committee has defined its areas of interest (which are also the areas of this report) as follows:

Logistics is the support of operating rocket vehicle systems by provision of required operating and maintenance instructions, spare parts, tools, test equipment, supplies, and supplementary technical personnel.

Operations are rocket-vehicle system field-tests, launchings, or exercises which investigate or evaluate the system's capability to carry out its assigned mission.

Since 1957, it has been increasingly clear that most rocket activities fall into two major categories: Weapon systems and space vehicles. Each of these is reported on separately, although most space vehicles are today propelled by adapted weapon system rockets.

To take up weapon systems first, *logistic* achievements included:

1. Initiation, at San Bernardino Air Material Area, of Ballistic Missile Logistic System Management using Electronic Data Processing Systems (EDPS).
2. Improvement in logistic support concepts resulting from studies of a man-machine-model conceived and operated by the Logistic Laboratory of the Rand Corporation.

From the operations standpoint, there were these developments:

1. R&D test-qualification of certain weapon systems and acceleration of the testing rate on others.
2. Establishment of a new national test facility, the Pacific Missile Range.
3. Deployment to a NATO country of an IRBM weapon system.
4. Commissioning of an ICBM weapon system.

In the space-vehicle area, this has been a year of emphasis on planning and preparation for future programs. Current programs have moved ahead cautiously.

Logistics for space transport and travel has become increasingly evident as a complex and pressing problem. Preflight logistic support of launching rockets differs little whatever the cargo. We are, however, beginning to sense two challenging in-flight logistic problems:

1. Maintenance and repair of functional satellites. Orbiting instruments will soon and continuously relay communications, supply navigational information, and survey the earth's weather. A rocketed service truck may well be required.
2. The entry of Man himself into space brings on a host of logistic problems which are today the object of serious study and planning in many organizations. Life (CONTINUED ON PAGE 164)

ABMA static-test tower is being modified to accommodate the 1.5 million-lb Saturn booster being developed for ARPA. Saturn position will be on right side of concrete tower. Jupiter is shown in test position on left side of tower here.

State of the Art, 1959

Magnetohyrodynamics

By Milton U. Clauser

DIRECTOR, PHYSICAL RESEARCH LABORATORY,

SPACE TECHNOLOGY LABORATORIES, LOS ANGELES, CALIF.

For the ARS Magnetohydrodynamics Committee

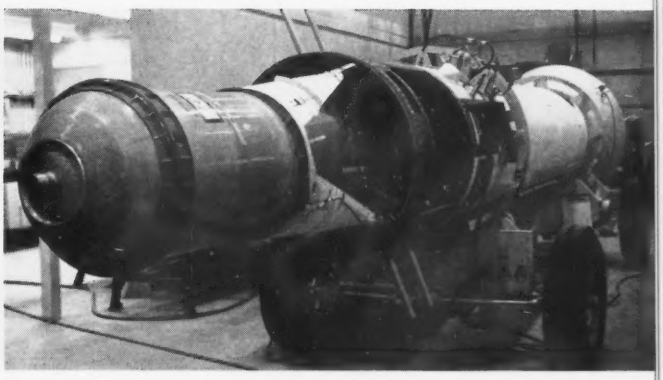
THE RISING INTEREST in magnetohydrodynamics is best illustrated by the rapidly increasing number of technical articles which are appearing. Bibliographies such as that compiled by Prof. Banks of Northwestern Univ. and Borman and Sherman of General Electric Co. show that up to 1953 about 10 papers were appearing each year. By now, the publication rate has increased nearly tenfold. Also, the field has rapidly broadened, as illustrated by the profusion of names which are being proffered, such as hydromagnetics, magnetogasdynamics, plasma physics, fusion physics, etc.

Historically, the field owes a great deal to the astrophysicists—such as Alfvén, Cowling, and Spitzer—who saw that an understanding of the interaction between electromagnetic fields and ionized gas particles would help explain the phenomena observed in our sun, other stars, and the galaxies. The field also owes a great deal to scientists such as Bennett, Langmuir, and Tonks, who studied electrical discharges in gases. As early as the 1930's these scientists foresaw that a magnetic field might confine a plasma.

The possibility of using magnetohydrodynamics to control the thermonuclear reaction aroused considerable interest in the early 1950's, not only in the U.S. but also in Great Britain and Russia. The U.S. program up to the Geneva meeting in September 1958 has been well described by Amas Bishop.[1] The technical problems were lucidly described by Post[2] in 1956. Up to that time, it is probably fair to say that the emphasis had been on building devices which it was hoped would be the forerunner of a prototype power-producing reactor. The instability problems which had been encountered had caused considerable concern, but were viewed as an obstacle which ingenuity would overcome. In fact, there was considerable optimism about the possibilities of obtaining a stable interface between the plasma and the magnetic field for devices like the pinch.

All Devices Plagued with Same Disease

At the Geneva conference,[3] when essentially all the nations of the world disclosed the fusion research work they had been doing, it became apparent that all of the devices seemed to be plagued with the same kind of disease. The symptoms were that, during the early part of a confinement cycle, recordings of voltage, current, local magnetic field, and radiation could be duplicated from shot to shot. But at one point, which was between a microsecond and a millisecond for various devices and seemed to vary with initial plasma density and other parameters, the readings suddenly exhibited a different character. The signals were often full (CONTINUED ON PAGE 134)



Expansion into major space operations: Left, Wernher von Braun and Maj. Gen. John P. Medaris look over model of Saturn vehicle, with its 1.5-million-lb-thrust clustered-engine first stage, now under development; center, a Mercury capsule with a CTL ablating heat shield takes shape at McDonnell Aircraft; right, assembled second (liquid) and third (solid) stages of Thor-Able III indicate flexibility of state of the art.

State of the Art, 1959

Missile and space-vehicle design

By Maxwell W. Hunter

ASST. CHIEF ENGINEER FOR SPACE SYSTEMS, DOUGLAS AIRCRAFT CO., SANTA MONICA, CALIF.

For the ARS Missile and Space Vehicle Committee

THE STATE OF THE ART in missile and space vehicle design has made spectacular advances since 1945. At the end of WW II, only a very few unmanned devices had been flown, and sophisticated guidance such as is required to intercept aircraft was virtually untried. The closest approach to a space vehicle was the German V-2 missile. This missile reached above the sensible atmosphere, but had a maximum speed of only 3500 fps. Although this was around five times faster than any manned aircraft had flown, it was only one-tenth the speed required for escape from the earth's gravitational field. It did, of course, pioneer the large rocket propulsion systems necessary for spaceflight.

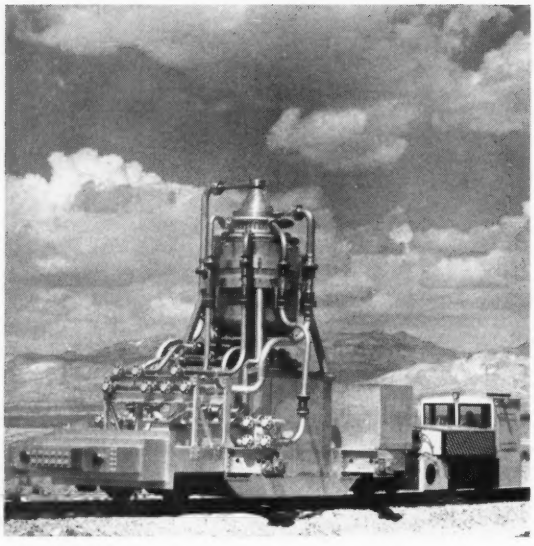
By Oct. 4, 1957, when Sputnik I was launched, many unmanned missiles of various categories had been flown in the U.S., and several had been successfully placed in operational use. Vast improvements in guidance techniques had been achieved, including solutions to the problems of aircraft interception as well as surface bombardment. Even the problem of ballistic-missile interception was under vigorous pursuit. From the point of view of advancing the space art, the most spectacular performers were the intermediate-range ballistic missiles, which had reached speeds of 15,000 fps, and certain test vehicle configurations which had approached speeds of 20,000 fps.

After Sputnik I was launched, the conversion of many of the military weapons into space-vehicle modes of operation, by utilizing additional stages and reducing payload weights, gave spectacular improvement in speeds and altitudes attained.

Space Operations to Date

Space-vehicle operations to date in this country include the following: Vanguard and modified Redstone missiles have reached orbital speeds with relatively small payloads. A Jupiter-boosted probe (NASA's Pioneer IV of March 3, 1959) exceeded escape speed and passed close to the moon, and Thor-boosted probes reached an apogee of 80,000 miles, placed a modest sized payload on a highly eccentric orbit, and placed several payloads on polar orbit. Also, an Atlas has boosted itself into orbit (Atlas-Score).

Just as with all missile (CONTINUED ON PAGE 86)



Successful testing of the Kiwi-A reactor confirmed important design concepts for rockets and gave valuable data on starting transients, radiations, and other motor characteristics.

State of the Art, 1959

Nuclear propulsion

By Chiao J. Wang

MANAGER, PROPULSION SYSTEMS DEVELOPMENT DEPT., SPACE TECHNOLOGY LABORATORIES, LOS ANGELES, CAL.

For the ARS Nuclear Propulsion Committee

THE YEAR 1958–1959 has witnessed steady progress and significant accomplishments in the field of nuclear propulsion. For the first time in history, nuclear propulsion of flight vehicles has become a subject of open discussion. The ARS organized the first technical session on nuclear propulsion at its annual meeting in the fall of 1958. The session has since started a parade of similar unclassified discussions sponsored by ARS and other technical societies. Various research and development programs for propulsion reactors have been making gradual but sure progress. There now seems to be a greater awareness of the potentialities of nuclear energy for flight-vehicle propulsion.

Rover Now in Fourth Year

The nuclear-rocket program Rover is in its fourth year. Its purpose is to investigate and demonstrate the feasibility and practicality of nuclear-rocket propulsion. A major accomplishment of this year was the successful test of the first test reactor, Kiwi-A, at the Jackass Flats test site in Nevada. The test has confirmed important design concepts and yielded valuable data on materials, controls, start transients, radiations, and other characteristics of the reactor. The success of this test is expected to contribute greatly to further progress of the program.

It now appears possible to design a flyable reactor with greater confidence, but many questions remain to be answered. For example, what would be the performance capabilities of a nuclear-rocket vehicle? How would a nuclear vehicle compare with its chemical counterpart? It is obvious that in the general field of nuclear rockets and vehicles a lot of work remains to be done.

The ramjet program Pluto is making progress in both the area of high-temperature nuclear reactors and ramjet engines. One of the most important steps is to actually design a reactor and test its characteristics. A facility is now under construction in Nevada for the testing of an engineering test reactor. Another area of investigation is that of high-temperature ceramic materials. In order to perform high-temperature tests, a test oven has been built at the Nevada site. The performance capabilities of nuclear ramjets provide another subject of investigation. Studies are now being actively conducted to determine suitable vehicles for nuclear-ramjet engines. The ANP program, with the aim of developing turbojet nuclear reactors for aircraft propulsion, has also maintained a steady pace of development.

There has been active work on new or advanced concepts of nuclear propulsion. Effects of dissociation and recombination have been explored for high-temperature reactors. The present reactor design has a temperature limitation in the neighborhood of 5000 R. At this temperature, no appreciable dissociation of hydrogen takes place. If the reactor core temperature can be raised to above 7000 or 8000 R, however, hydrogen will dissociate to an appreciable degree, and very significant improvement of rocket performance will result. It appears that temperatures on this order may be attainable. In addition, possibilities of heating the propellant to a temperature above the reactor-core temperature have also been examined. Proposals to achieve this high temperature range from mechanical devices to electromagnetic means. It appears that, in principle at least, this approach may lead to significant increase in specific impulse.

Gaseous cavity reactors have received some attention in the form of basic research and open discussions. Studies made (CONTINUED ON PAGE 136)

Shown here in an artist's depiction, the giant NRL-designed 600 ft-diam-dish radio telescope, being built by the Navy to probe the universe to a distance of 38 billion light years (19 times the range of the Palomar telescope), reflects the opening up of the whole field of radio astronomy.

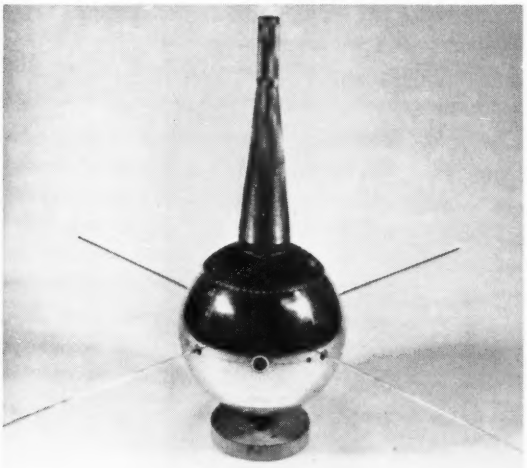
State of the Art, 1959

Physics of the atmosphere and space

By Milton Greenberg

PRESIDENT, GEOPHYSICS CORPORATION OF AMERICA, BOSTON, MASS.

For the ARS Physics of the Atmosphere and Space Committee



The last of the pioneering Vanguard series, Vanguard III, carrying a manometer and radiation experiments, symbolizes the great advances in near-space and upper-atmosphere studies made in the past year.

THE PAST YEAR has been one of continued growth in new areas and more detailed analysis of the results in other areas of physics of the atmosphere and space. This field, not strictly speaking an internally consistent one, is still in the process of growth and consolidation; its disciplinary aspects were drawn from the basic and applied sciences the past year.

In asking what areas progressed the most during the year, one can look to the discovery and partial analysis of the Great Radiation Belts. Presently, the morphology and the dynamics of this particular area of space are undergoing considerable experimental and theoretical study.

There have also been increased activities and very large programs started in radio and rocket astronomy. Of particular note is the opening up of the whole field of radar astronomy.

The entire problem of the effect of the traversal of objects through space and in near-space also received much attention, leading to considerable addition of the literature on the (CONTINUED ON PAGE 101)

State of the Art, 1959

Power systems

By A. M. Zarem

PRESIDENT, ELECTRO-OPTICAL SYSTEMS, INC.

PASADENA, CALIF.

For the ARS Power Systems Committee

SPACE-VEHICLE power requirements seem to be following an almost exponential growth. While current probes require only 5 to 10 watts, space vehicles already planned for mid-1964 will require 100 kw. These demands are for instrumentation and communications. The advent of electrical propulsion would impose multimegawatt requirements.

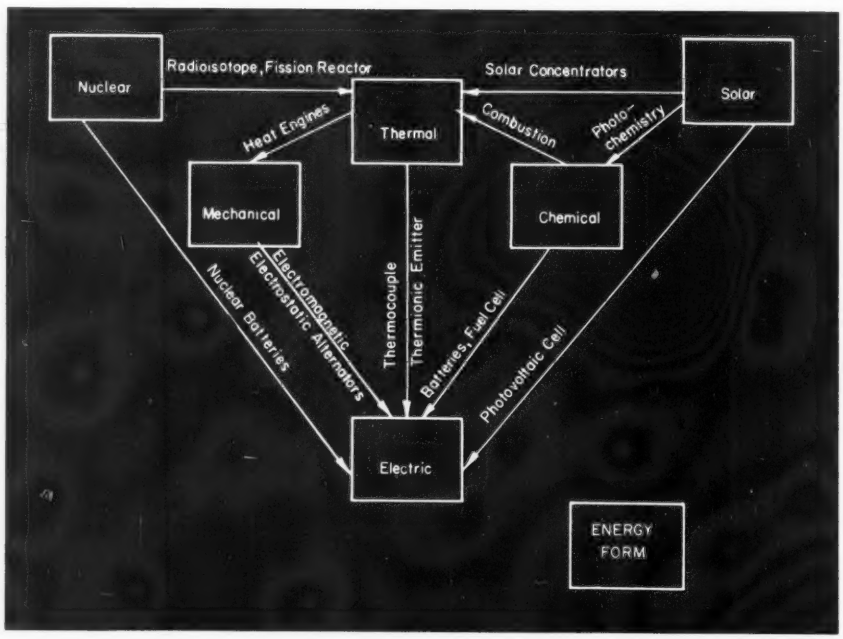
Power systems are presently available to satisfy missile requirements at power levels on the order of 1 to 50 kw for durations of 30 sec to 30 min. Missile systems use chemical fuels in electrochemical batteries and turboalternator units. Silver-zinc batteries, for example, can provide as little as 12.5 lb/kwh; however, weight needed for automatic battery activation may double this figure. Current turbine-driven power systems consume monopropellant fuel at a rate of about 8.5 lb/kwh, to which must be added the weight of the fuel tank, rotating machinery, etc.

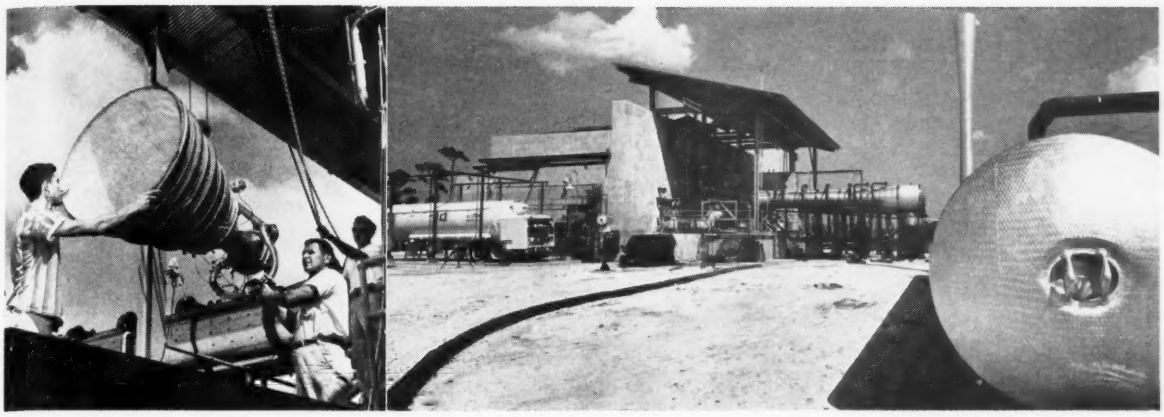
Because of their low fixed weight and relatively high conversion efficiency, chemical systems will continue to provide weight advantages in orbital and space vehicles for low-energy applications. At high power levels and/or long durations, however, chemical fuel weight becomes prohibitively large, and systems based on solar or nuclear energy sources must be used. These systems are generally characterized by a high fixed weight and are rated by a specific weight figure (lb/kw).

A wide variety of systems appear suitable for space application. The energy converters and processes which may be used in converting from solar, nuclear, and chemical to electrical energy are shown in flow-chart form below. Several programs are currently developing hardware based on nuclear and solar energy sources in the 100 watt to 10 kw power level region for use in the early 1960's. The relative advantages of each system in terms of weight and other factors will depend on the success of these developments. Systems being actively developed include the following:

Fuel Cell. The fuel cell is basically an electrochemical battery in which the chemical reactants are continually fed into and withdrawn from the cell. In this manner, high-energy reactants such as hydrogen and oxygen can be used; 8 lb/kwh, for example, appears possible (CONTINUED ON PAGE 89)

Sources of Electrical Power





Liquid hydrogen rocket technology has reached the level of everyday practice at Pratt & Whitney's Florida development center, where the 15,000-lb-thrust XLR-115 engine (nozzle, left) for the Centaur rocket is well into the development cycle on stands like the one at right. Four stands like this at the Florida center rate 300,000-lb thrust. The engine exhausts into partial vacuum in large tubes projecting horizontally from the right of the stand.

State of the Art, 1959

Propellants and combustion

By John L. Sloop

CHIEF, ROCKET ENGINES BRANCH, NASA LEWIS RESEARCH CENTER, CLEVELAND, OHIO

For the ARS Propellants and Combustion Committee

THE PAST YEAR in propellants saw a consolidation of trends developing over the past several years. The big boosters (often referred to as trucks) for military and space experiment roles use oxygen and kerosene, and so will the 1.5-million-pound-thrust booster now under development for NASA. Interest continues, however, on storable combinations that do not require refrigeration. And work on solid propellants is expanding, with great expectations of achieving simplicity and readiness with large grains in such missiles as Polaris and Minuteman.

The year marked great activity on the high-energy propellants, both solid and liquid. Some activities must remain unnamed in the interests of security. To me the highlight of the year in propellants was the selection of high-energy liquid propellants—hydrogen and oxygen—for an upper-stage vehicle. The Centaur engine (Pratt & Whitney) and vehicle (Convair-Astronautics), which could scarcely be mentioned a year ago, is rapidly taking shape and will use liquid hydrogen and oxygen.

This combination, well known to rocket men for many years, was worked on a decade ago by Ohio State Univ., Aerojet-General, the Jet Propulsion Laboratory, and others. I remember a high-level meeting of rocket men from across the country almost a decade ago when several of us urged work on a vehicle using hydrogen as a fuel. The advantage of its high specific impulse was unquestioned, and we argued that many of the problems regarding its low density and temperature could not be met and resolved until an attempt was made to use it in a vehicle. It is known, for example, how to make light tanks; but a big unknown is how well we can control the storage of hydrogen and other cryogenics in space for a considerable period of time and still get reliable propulsion after long hours of engine inactivity.

Approaching Operational Status

There are, of course, many other problems, but the rapid pace of cryogenic technology, told by our journals and our conferences, indicate that liquid hydrogen is approaching operational status in spaceflight applications.

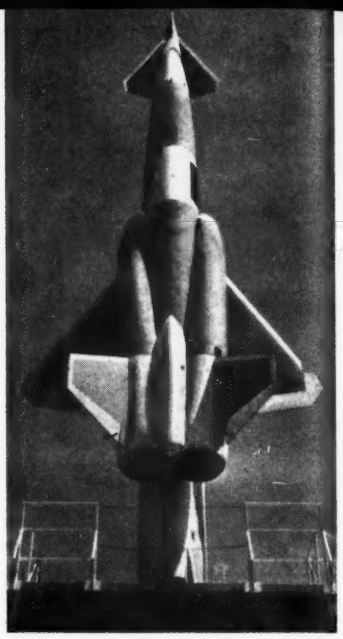
For example, see the survey article by Robert Jacobs in the April 1959 (CONTINUED ON PAGE 74)

State of the Art, 1959

Ramjets

By the Astronautics Staff

FOR THE ARS RAMJETS COMMITTEE



The promise of Navaho (shown on Thor booster), which broke the ice for large ramjets, remains to be fulfilled.

THE OLD RAMJET STORY, the quarter century which brought the flying stovepipe limited recognition in the form of Mach 2 to 3 interceptor missiles, namely Bomarc and Talos, has ended for all but the most practical purposes. The reader will find this story and its precedent history in W. H. Avery's very fine article in the November 1955 *Jet Propulsion* entitled "Twenty-Five Years of Ramjet Development."

The Special Ramjet Section of the April 1959 *Astronautics* surveys ramjet trends and development. The status of ramjet theory and development has not changed appreciably in the past year or more, and the concluding statements of Gordon Dugger's "A Future for Hypersonic Ramjets" from that issue may be taken to summarize prospects for ramjets, and suggest the probable course of developments in the classified area:

"Among air-breathing propulsion systems, the ramjet is the only engine which will be practical beyond Mach 4.

"The current generation of ramjet engines has an order-of-magnitude advantage in fuel economy over current rocket engines, and the ramjet will retain its superiority well into the hypersonic regime.

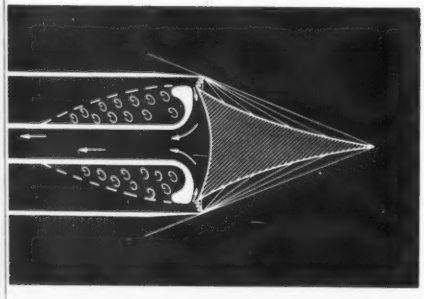
"For flight within the earth's atmosphere, a ramjet-powered vehicle will have a tremendous advantage in weight, range, or payload over a rocket-powered vehicle.

"It appears that ramjet-powered flight will be feasible at speeds approaching (and possibly exceeding) Mach 10.

"It can be demonstrated that there are many valid reasons why a terrestrial or surface-to-surface vehicle should remain within the atmosphere (though most of the military implications cannot be discussed here).

"For putting a series of large payloads into space, a recoverable, maneuverable air-breathing launcher would have unique advantages in economy and reliability."

Hypersonic Inlet



Conventional Ramjet Still Most Practical

"Of the ramjet modifications discussed, the conventional ramjet (or some slight variation of the configuration presented for it) appears more likely to find application than either the supersonic combustion or standing-wave type, mainly because of the difficulty of fuel injection and mixing in shock-free supersonic flow.

"Though much R&D work is still needed, particularly in such areas as hypersonic inlets, materials, and cooling techniques, and real-gas kinetics (the recombination problem), Mach 7 to 10 engines should be a reality by about 1965, and Mach 7 transports could be flying by 1970."

The significant applications inherent in (CONTINUED ON PAGE 171)

State of the Art, 1959

Solid rockets

By Ivan E. Tuhy

HEAD, ROCKET PROPULSION STAFF,

MARTIN CO., BALTIMORE, MD.

For the ARS Solid Rockets Committee

THE PAST YEAR has found the solid rocket industry hard at work in the research and development of larger rocket motors, higher specific impulse propellants, propellants with better physical properties, high mass (propellant) fractions, methods for vector control, and total impulse control (thrust termination). There have been significant accomplishments in most of these endeavors. With the appropriation of more funds for the research and development of solid rockets, these accomplishments were inevitable. If such funds had been directed toward solids many years ago, we would doubtless be farther along the road with larger, more efficient, and better fueled rockets now.

Let us look at some of the progress so far.

ARPA is spending more than $15 million on propellant study with 54 contracts in the following seven research areas:

1. Integrated program concept, which includes chemical studies aimed at the synthesis of new ingredients or chemicals which can be formulated, processed, cast, and cured, and otherwise satisfy the required physical and ballistic properties.
2. Behavior of propellants when subjected to temperatures during cure.
3. Synthesis of new oxidizers, light-metal fuels, and chemical techniques.
4. Propellant research utilizing new ingredients.
5. Inert parts study for propellants with flame temperatures in excess of 5000 F; present propellants reach 6000 F.
6. Nondestructive testing techniques.
7. Basic research on combustion phenomena.

During the past year, the rocket industry has been deeply engrossed in the development of propellants with specific impulse significantly higher than currently available. Most of this work has been theoretical, but indications are that significant improvements are possible in practice. ARPA hopes to have a propellant with a specific impulse of 280 to 300 sec in five years, and is sponsoring research and development programs throughout the chemical and rocket industry to achieve this end. This increase will add up to 30 per cent gain in the payload capacity for a given vehicle. In anticipation of such a specific impulse, efforts are being made to make the chemicals available in a desensitized state (possible encapsulation), to evaluate experimentally processing attributes, and to determine the physical and mechanical properties which will offer the advantages of economy, sim- (CONTINUED ON PAGE 146)

The formidable maw of this country's largest propellant mixer, a 350-gal steel-bladed giant at Grand Central Rocket Co., symbolizes the advance of solid rocketry to very large sizes and toward continuous mixing and pouring operations.

Andrew G. Haley (second from left), ARS-IAF representative to the ITU Radio Conference at Geneva, Switzerland, which is dealing with allocations of radio frequencies for astronautical purposes, poses with members of the Russian delegation to the meeting. Left to right, L. Kopitine, N. Krasnoselsky, A. Badalov (chairman of the delegation), and B. Elkina.

State of the Art, 1959

Space law and sociology

By Andrew G. Haley

HALEY, WOLLENBERG, AND KENEHAN, WASHINGTON, D.C.

For the ARS Space Law and Sociology Comm.

AS THIS is the initial annual report on developments in the social sciences relating to astronautics—including space law and sociology—a few introductory words are necessary. Fortunately, from its very inception, ARS has recognized the study and application of the social sciences as a Society objective. Over the years, persons primarily interested in the social sciences have been elected to the office of president of the Society, and these have included an expert in public psychology, a medical doctor, and a lawyer.

The position of the social sciences was clarified during the presidency of Richard W. Porter, when the objectives of the Society were restated. Specific recognition of the social sciences also was afforded by ARS in the creation in 1952 of the Ad Hoc Space Flight Committee and in the inclusion in many programs since that date of papers on all aspects of the social sciences. We now have the social sciences further recognized by the creation in 1958 of the large and active ARS Technical Committee on Space Law and Sociology.

The considered decisions of ARS have been paralleled by other astronautical societies throughout the world. Even the Academies of Sciences of Eastern European nations include the social scientists among their leading members. For example, lawyers form a prominent segment of the Academy of Sciences of Czechoslovakia, while the British Interplanetary Society has devoted much of its publication space and public lectures to the social sciences. As a result of this basic framework, the International Astronautical Federation likewise has given fundamental recognition to the social sciences and in particular to jurisprudence.

In reviewing the developments of the past year, it is appropriate to begin with the First Colloquium on the Law of Outer Space held at The Hague on August 29, 1958. The *Proceedings* of that Colloquium have been published (Springer-Verlag, Vienna, 127 pp.). At this Colloquium, an integral part of the Ninth IAF Congress, speakers from a score of nations discussed questions concerning allocation of space frequencies; avoidance of interference between space vehicles and aircraft; questions of freedom of outer space for exploration and use; liability for injury or damage caused by space vehicles; questions concerning re-entry and landing of space vehicles; and questions concerning the determination of sovereignty in outer space and specifically the jurisdictional point where outer space begins. The Hague Colloquium anticipated by many months all the points made in the Report of the Legal Committee of the UN Ad Hoc Committee on the Peaceful Uses of Outer Space.

Conference Had Striking Results

The next important development was the ARS Space Law and Sociology Committee Conference held on March 20, 1959, in New York City. This meeting had three striking and surprising results.

First, an officially designated Subcommittee of the House Committee on Science and Astronautics attended in a body. The (CONTINUED ON PAGE 142)

State of the Art, 1959

Structures and materials

By George Gerard

ASSOCIATE DIRECTOR OF RESEARCH, COLLEGE OF ENGINEERING, NEW YORK UNIV., NEW YORK, N.Y.

For the ARS Structures and Materials Comm.

AS A BALANCE to the current emphasis on missiles and space vehicles, the completion and maiden powered flight of the X-15 mark events of major importance. Not only does powered flight of the X-15 constitute a significant forward step in the evolution of manned systems, but it also portends a virtual revolution in the design and fabrication of hypersonic structures.

Further significant developments in this area have come from the DynaSoar program. Recently completed studies have led to a much greater understanding and appreciation of crucial design-structures-materials interactions involved in this advanced hypersonic concept. The current solutions for some of the intense aerodynamic-heating problems encountered in this program are pushing forward the frontier of materials technology. Indeed, some very significant composite structural-material developments are evolving from this program.

In the missile field, the success of the pressure-stabilized shells employed in Atlas has demonstrated the reliability of this new structural concept. The emergence of this approach on a production basis has provided missile and space-vehicle designers with a competitor for the more familiar stiffened-shell configurations.

Recognition that composite structure-material systems hold great promise for re-entry vehicles is emerging from the success obtained with ablation-type nose cones. It is now apparent that here are a broad range of thermal protection systems which have potential application within the wide spectrum of thermal conditions associated with ballistic, orbital, and glide re-entry.

Thermal protection systems that are based upon absorptive principles are generally time limited, but not necessarily heat-flux limited. Consequently, they are particularly attractive for extreme thermal environments of short duration associated with ballistic and orbital re-entry. Because absorptive systems are inherently time limited, however, glide re-entry solutions generally employ radiative principles which are inherently heat-flux but not time limited.

Battelle Memorial Institute photo of uncoated (left) and siliconized molybdenum wire at 3000 F in air dramatizes progress made in protective coatings for this Space-Age metal.

Both the radiative thermal protection system and the "hot" structures approach depend to a large measure upon the development of relatively thin gauge sheets of refractory metals or ceramics. The current research and development efforts on these materials are essentially in response to this requirement.

Progress Made on Molybdenum Coatings

The use of molybdenum-, columbium-, or tungsten-base alloys requires the successful development of oxidation-resistant coatings, with particular emphasis on their application to complete structures. Significant progress has been made in the development of such coatings for molybdenum, as can be inferred from the photo on this page.

The development of high-strength precipitation-hardening stainless steels with satisfactory weldability and brazability has resulted in the selection of this material for the Mach 3 generation of manned aircraft currently being (CONTINUED ON PAGE 158)

Launching-silo test facility under construction for the solid-propellant Minuteman missile at Edwards AFB.

State of the Art, 1959

Test facilities and support equipment

By Richard A. Schmidt

TECHNICAL ASSISTANT TO THE DIRECTOR, DIRECTORATE OF ROCKET PROPULSION AND MISSILES, AIR FORCE FLIGHT TEST CENTER, EDWARDS AFB, CALIF.

For the ARS Test Facilities and Support Equipment Committee

FLIGHT-TEST and static-test facilities for space vehicles and ballistic missiles have been developed into efficient operating systems. Test-facility operation has seldom been responsible for test failures or delays to individual tests. However, there is still a need for new facilities to advance the state of the art of vehicles and propulsion systems.

Today, the missile ranges have a firing schedule which is several times the firing rate of a year ago. Static-firing tests of propulsion systems have also increased appreciably. These static development tests are now approaching one firing per shift per day on the largest liquid rocket engines under development. The thrust capacity of facilities under design has gone from 500,000 lb a few years ago to over 5,000,000 lb today. Along with this increase in thrust, the size of rocket propulsion systems under design has gone from a height of less than 100 ft to a height of over 300 ft with corresponding difficulty in handling equipment and accessories. Additional complexity is involved because of the increased number of stages, the move to more exotic propellants, and the incorporation of man in the vehicle. Fortunately, while the number of channels for control and data recording has increased proportionately, the equipment has been improved so that the testing can be accommodated with a reasonable size of control station.

Several new kinds of facilities have been activated. Nuclear-rocket tests have been conducted. The radiation associated (CONTINUED ON PAGE 169)

Control console for rapid servicing of propellants into the Atlas missile.

State of the Art, 1959

Underwater propulsion

By George F. Wislicenus

DIRECTOR, GARFIELD THOMAS WATER TUNNEL, AND PROFESSOR OF AERONAUTICAL ENGINEERING, PENNSYLVANIA STATE UNIV., UNIVERSITY PARK, PA.

For the ARS Underwater Propulsion Committee

THE PREVAILING method of driving submerged bodies uses conventional marine propellers, an art over a hundred years old. Jules Verne's Nautilus, a sleek steel body of revolution, was driven by a single propeller to the maximum speed of 50 knots.

The major achievement of our day, which focuses attention on problems of underwater propulsion, is obviously the successful development of a nuclear powerplant for submarines. Its present status was described recently by Admiral Rickover and his staff.[1] It was natural to employ conventional marine propellers for this first application of a new source of power. In light of this development, the propulsion of submerged bodies rests today firmly on the highly developed art of marine propeller design, well described in the existing literature.[2-3]

Nuclear Power Revolutionizing Field

There can be no doubt that nuclear power, so uniquely suited for underwater propulsion, is revolutionizing this field not only in direct connection with this power source but also in adjacent fields, such as underwater weapons (i.e., small submerged bodies) and underwater transport, which may well lead to the use of very large submerged bodies. On the basis of similarity considerations, such as suggested by references 4 and 5, it would not be surprising if large submerged bodies were found to constitute potentially the most economical form of overseas transport for certain bulk goods at reasonably high speeds. This expectation is based in part on the fact that the ocean, even at moderate depths, constitutes hydrodynamically a very quiet medium which may permit the use of extremely simple and inexpensive hull structures.

While propulsion by means of conventional propellers is well covered by the Society of Naval Architects and Marine Engineers, the AMERICAN ROCKET SOCIETY may be expected to focus its attention on various forms of jet propulsion applicable to the underwater field. Although underwater jet propulsion has not yet found general acceptance, it would not be surprising if the availability of new power sources such as nuclear power would force the engineers to consider this type of thrust producer in addition to the conventional propeller.

There are three reasons why jet propulsion may take the place of conventional marine propellers:

With respect to the velocity of flow, the hydrodynamic limit corresponding to the old "acoustic barrier" of aeronautics is *cavitation*, i.e., the vaporization of liquid due to local reductions in pressure. It is possible to overcome the cavitation limits of marine propellers by some form of hydraulic jet propulsion, essentially as Mach number limits of aircraft propellers can be avoided by the use of turbojet or rocket engines.

The second reason is related to machinery weight. It should be remembered that the Mach number limit of propellers is only one of the reasons for using jet propulsion with aircraft. The other reason is the weight of conventional powerplants and propellers, which would be prohibitive if used to propel aircraft at speeds over, say, 500 mph. There is good reason to expect that the same considerations of machinery weight will lead to the adoption of jet propulsion in the underwater field for high travel speeds.

Drag-to-Weight Ratio Important

The likelihood of such a development can be judged from the ratio of the drag to the weight of the propelled body. In water the drag of relatively small bodies approaches or exceeds the weight of a buoyant body at more or less conventional speeds of travel. Large buoyant bodies have more favorable drag-to-weight ratios, but even then this ratio is often comparable to the drag-to-lift ratios in the supersonic regime of aerial flight. Thus, the machinery-weight problems of (CONTINUED ON PAGE 154)

Washington welcomes ARS

Attendance of 7000 expected at Annual Meeting in the nation's capital Nov. 15-19 . . . McCone, Sutton, Pickering, Schriever to address the largest meeting in the Society's 29-year history

By Rod Hohl

MEETINGS MANAGER, AMERICAN ROCKET SOCIETY

THE RAPID GROWTH of the AMERICAN ROCKET SOCIETY will be dramatically demonstrated at this year's Annual Meeting when an expected 7000 persons, more than the entire membership of the Society as recently as two years ago, gather for the largest meeting ARS has held in its 29-year history.

The meeting, to be held in the Sheraton-Park Hotel in Washington, D.C., Nov. 15–19, will include more than twice as many unclassified sessions as last year's 11, with more than 100 technical papers scheduled for presentation. This will require for the first time quadruple unclassified sessions on two days in addition to an evening session on Monday, Nov. 16, and the National Capital Section's session the following night.

In addition to the outstanding technical program (see page 54), such speakers as George Sutton, chief scientist of ARPA and former ARS president; William Pickering, director of the Jet Propulsion Laboratory of the California Institute of Technology; and Brig. Gen. Homer A. Boushey, Director of Advanced Technology, Deputy Chief of Staff for Development, Hq., USAF, will address luncheons during the meeting.

Also outside the technical program, the ARS annual business meeting will be held Monday afternoon. At this time, the membership will be given a report on the year's progress and will elect new officers for the coming year. The Section Delegates Conference to be held the morning of the same day will give representatives of all 51 ARS Sections a chance to let down their hair with officers and staff members, get their complaints aired and any questions they may have, answered.

Highlight of the meeting will come Wednesday evening at the annual ARS Honors Night Dinner, to be preceded by a reception under the sponsorship of Aerojet-General Corp. for all banquet guests. Speaker at the dinner will be John A. McCone, chairman of the Atomic Energy Commission, who will talk on "The Influence of Nuclear Technology on Rockets and Space."

Following its tradition, the Society will honor five individuals for their outstanding contributions to missile and spaceflight development with its annual awards. Completing a year in which great strides were made, this year's selection of award winners is particularly significant. For outstanding work in liquid rockets, Samuel K. Hoffman, vice-president and general manager of Rocketdyne, and an ARS board member, was selected to receive the Robert H. Goddard Memorial Award. The C. N. Hickman award for outstanding work in solid rockets will go to Dr. Ernest Roberts, manager of research for Aerojet-General's Solid Rocket Plant.

Other Award Winners

Professor Ali Bulent Cambel, chairman of the Mechanical Engineering Dept. of Northwestern Univ., was chosen to receive the G. Edward Pendray Award for outstanding contribution to rocket and astronautical literature. The ARS Astronautics Award will be presented to Dr. Walter Dornberger, vice-president–engineering of Bell Aircraft Corporation, for outstanding contribution to the advancement of spaceflight. The James H. Wyld Memorial Award for outstanding application of rocket power will go to Karel J. Bossart, assistant to the vice-president–engineering at Convair.

In addition, two ARS student awards of $1000 each for the outstanding papers on astronautics or a related subject in student competition, will be awarded by Chrysler Corp. to the best undergraduate entrant and by Thiokol Chemical Corp. to the best graduate entrant.

Reflecting the rapidly expanding field of astronautics, ARS will award a record 21 Fellow Memberships, an honor bestowed upon selected persons who have distinguished themselves in the field of rocketry or spaceflight or who have contributed outstanding service to the Society. These memberships will go to Kurt Stehling of National Aeronautics and Space Administration, Raemer Schreiber of Los Alamos Scientific Laboratory, Milton Rosen of National Aeronautics and Space Administration, Eberhard F. M. Rees of Army Ballistic Missile Agency, Walter T. Olson of NASA's Lewis Research Center, Lester Lees of California Institute of Technology, Kurt H. Debus of Army Ballistic Missile Agency, John I. Shafer of Jet Propulsion Laboratory, William Avery of Johns Hopkins Univ., Maj. Gen. L. I. Davis, assistant deputy chief of staff, development, USAF, and Thomas F. Morrow of Chrysler Corp.

Additional Fellow Memberships will be awarded to Homer J. Stewart of National Aeronautics and Space Administration, James Van Allen of State Univ. of Iowa, William G. Purdy of The Martin Company, T. Keith Glennan of National Aeronautics and Space Administration, Richard D. Geckler of Aerojet-General Corp., Adolph L. Antonio of General Tire & Rubber Co., David A. Young of Aerojet-General Corp., Kurt Berman of General Electric Co., Robert M. Lawrence of Thiokol Chemical Corp. and ARS treasurer, and James J. Harford, ARS executive secretary.

Astronautical Exposition Set

The meeting will also feature an Astronautical Exposition (see page 55), to be held in the Exhibit Hall of the hotel and an auxiliary area on the lobby floor covering a combined area of 14,000 sq ft. Some 70 exhibits from the nation's foremost missile and spaceflight equipment manufacturers will be displayed, illustrating much of the progress made in the field in the past year.

Other meeting highlights include a Student Conference, to be held on Thursday morning, and another in the popular series of ARS Marketing Symposiums, scheduled for Tuesday afternoon.

The complete program for the meeting will be found on the following pages.

Aerial view of Washington's Sheraton-Park Hotel, scene of the ARS 14th Annual Meeting and Astronautical Exposition Nov. 15–19.

Annual Meeting Program

Sunday, November 15

MIXER

5:00–7:00 p.m. — **Sheraton Hall**

Monday, November 16

GUIDANCE

9:00 a.m. — **Sheraton Hall South**

Chairman: Newell D. Sanders, National Aeronautics and Space Administration, Washington, D.C.

Vice-Chairman: Peter Castruccio, Westinghouse Air Arm Div., Baltimore, Md.

✦An Orbiting Astronomical Telescope Design Study, I. A. Schroader and J. G. Chubbuck, Applied Physics Laboratory, The Johns Hopkins Univ., Silver Spring, Md. (912-59)

✦Investigation of Possible Satellite Position-Sensing Methods, Rudy R. Mueller, Autonetics Div., North American Aviation, Downey, Calif. (913-59)

✦Guidance Requirements for Mars and Venus Probes, F. H. Kierstead, Goodyear Aircraft Corp., Akron Ohio. (914-59)

✦The Rotating Pendulum Accelerometer, Samuel Schalkowsky and Henry F. Blazek, Ford Instrument Co., Long Island City, N.Y. (915-59)

PHYSICS OF THE ATMOSPHERE AND SPACE

9:00 a.m. — **Continental Room**

Chairman: Homer Newell, National Aeronautics and Space Administration, Washington, D.C.

Vice-Chairman: S. Fred Singer, Univ. of Maryland, College Park, Md.

(Program to be announced)

GAS WAVE PHENOMENA

9:00 a.m. — **Burgundy Room**

Chairman: A. K. Oppenheim, Univ. of California, Berkeley, Calif.

Vice-Chairman: B. E. Gammon, National Aeronautics and Space Administration, Washington, D.C.

✦Theory of Structure of Gaseous Detonation, Joseph O. Hirschfelder and Charles F. Curtiss, Univ. of Wisconsin, Madison, Wis. (921-59)

✦Theoretical Analysis and Experimental Measurements of Detonation Induction Distances at Atmospheric and Elevated Initial Pressures, Loren E. Bollinger, Michael C. Fong, and Rudolph Edse, The Ohio State Univ., Columbus, Ohio. (922-59)

✦Methods of Predicting Composition Limits for Detonation of Hydrogen-Oxygen-Diluent Mixtures, R. W. Patch, United Aircraft Corp., East Hartford, Conn. (935-59)

✦Simultaneous Measurements of Conductivity and of OH Radiation in H_2—O_2 Detonation Waves, F. Jaarsma and A. E. Fuhs, Northwestern Univ., Evanston, Ill. (923-59)

✦The Effect of Flame Configuration on Combustor Performance, C. C. Miesse, Armour Research Foundation, Chicago, Ill. (924-59)

SECTION DELEGATES CONFERENCE

10:00 a.m. — **Caribar Room**

Chairman: Wernher von Braun, Chairman, ARS Membership Committee.

Vice-Chairman: J. Preston Layton, Vice-Chairman, ARS Membership Committee.

LUNCHEON

12:30 p.m. — **Sheraton Hall North**

Toastmaster: William H. Roennau, Acting President, ARS National Capital Section.

Speaker: George P. Sutton, Chief Scientist Advanced Research Projects Agency, Washington, D.C.

ION PROPULSION

2:30 p.m. — **Sheraton Hall South**

Chairman: Robert H. Fox, Univ. of California Lawrence Radiation Laboratory, Livermore, Calif.

Vice-Chairman: Robertson Youngquist, Advanced Research Projects Agency, Washington, D.C.

✦Experimental Studies with Small Scale Ion Motors, R. C. Speiser, C. R. Dulgeroff, and A. T. Forrester, Rocketdyne, North American Aviation, Canoga Park, Calif. (926-59)

✦Physics of the Ion Thrust System, Raymond Fox, Univ. of California Lawrence Radiation Laboratory, Livermore, Calif. (927-59)

✦Ion Propulsion Systems: Experimental Studies, Sam Naiditch, R. M. Worlock, D. Zuccaro, D. Barker, M. P. Ernstene, L. R. Gallagher, and J. Mullins, Electro-Optical Systems, Inc., Pasadena, Calif. (928-59)

✦Thrust Multiplications by Successive Acceleration in Electrostatic Ion Propulsion Systems, David B. Langmuir and B. R. Cooper, Thompson Ramo Wooldridge, Inc., Los Angeles, Calif. (929-59)

BIO-INSTRUMENTATION IN SPACE RESEARCH VEHICLES

2:30 p.m. — **Continental Room**

Chairman: Brig. Gen. Don D. Flickinger, Headquarters, Air Research & Development Command, Andrews AFB, Md.

Vice-Chairman: Eugene Konecci, Douglas Aircraft Co., Santa Monica, Calif.

✦Objectives of Bio-Instruments, Al Heatherington, Headquarters, Air Research & Development Command, Andrews AFB, Md. (930-59)

✦Viability Indicators, Bob Clark, School of Aviation Medicine, Randolph Field, Texas. (931-59)

✦Reliability of Bio-Packs Test Instrumentations, Lt. Bruce Pine, Air Force Ballistic Missile Div., Inglewood, Calif. (932-59)

✦Instrumentation of Nervous Systems for Study of Behavior, Ross Adey, Univ. of California Medical Center, Los Angeles. (933-59)

✦Future Requirements for Improved Bio-Instrumentation Techniques. Panel Discussion with above authors.

PROPELLANTS AND COMBUSTION

2:30 p.m. — **Burgundy Room**

Chairman: Jerry Grey, Princeton Univ., Princeton, N.J.

Vice-Chairman: Arthur A. Kovitz, Northwestern Univ., Evanston, Ill.

✦The Stability of Laminar Flames, Russell E. Petersen, Univ. of Kansas, Lawrence, Kan., and Howard W. Emmons, Harvard Univ., Cambridge, Mass. (936-59)

✦An Experimental Method of Measuring Intensity of Turbulence in a Rocket Chamber, Martin Hersch, Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio. (937-59)

✦Metal Combustion Processes, Irvin Glassman, Princeton, Univ., Princeton, N.J. (938-59)

✦Liquid Ozone as a Rocket Propellant, J. Preston Layton, Princeton, Univ., Princeton, N.J. (939-59)

ANNUAL ARS BUSINESS MEETING

4:00 p.m. — **Caribar Room**

BANQUET SPEAKER

John A. McCone
AEC Chairman

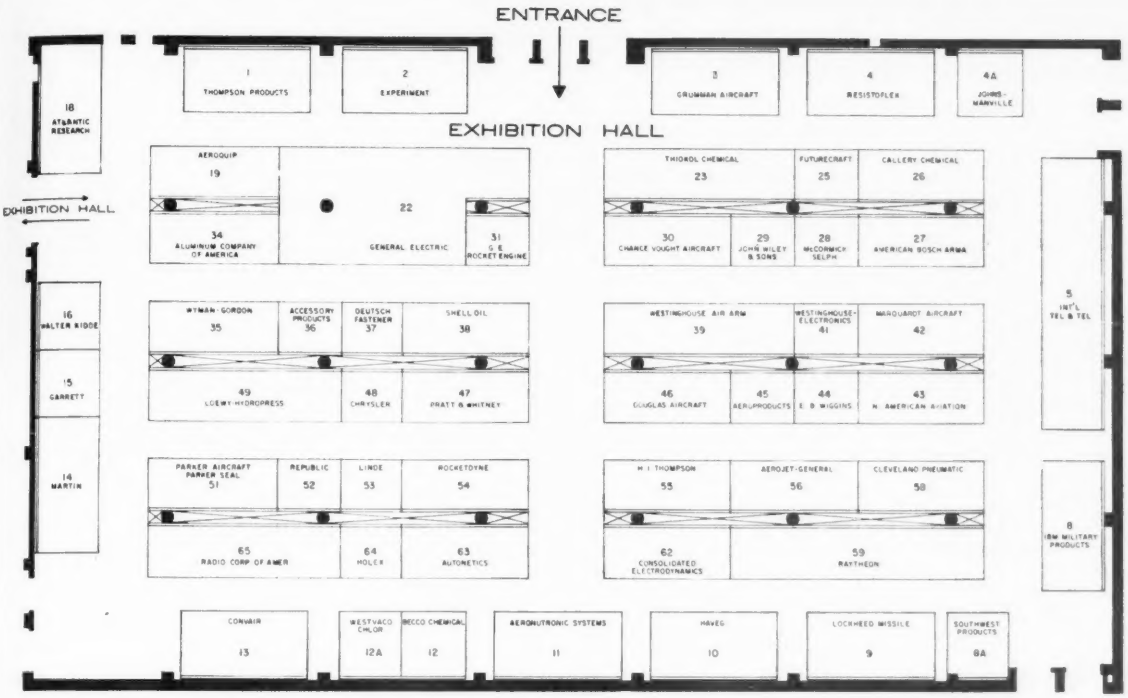
LUNCHEON SPEAKERS

Brig. Gen. H. A. Boushey
AF Adv. Tech. Chief

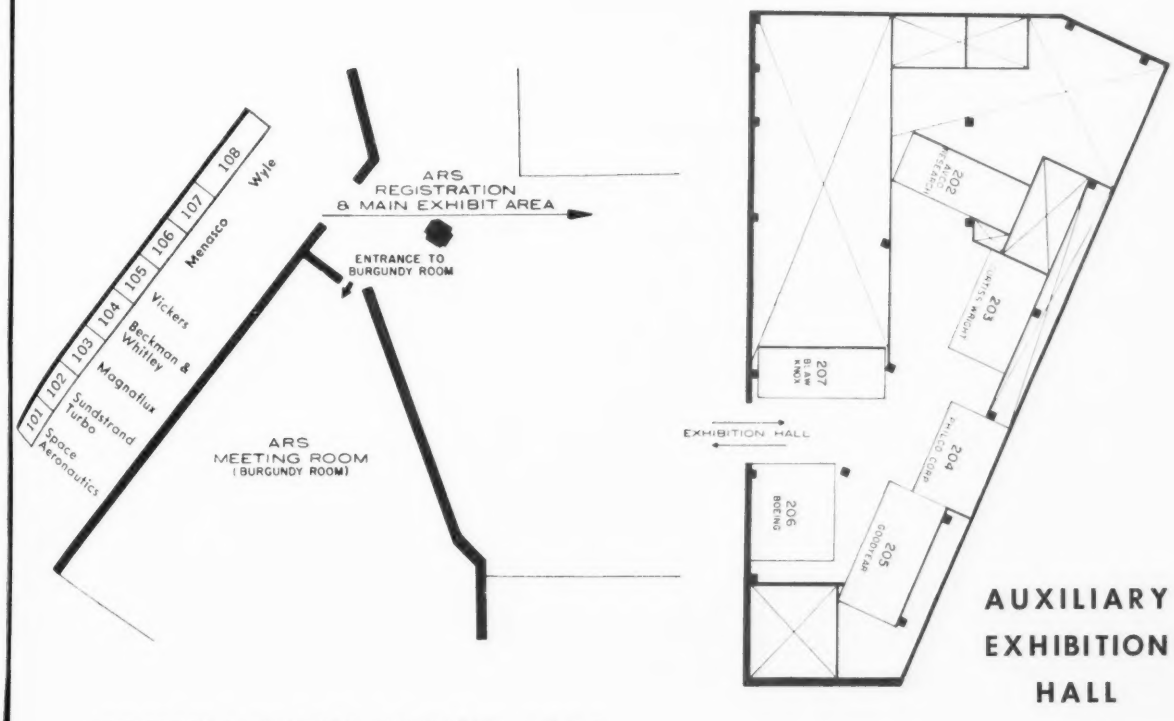
George P. Sutton
ARPA Chief Scientist

W. H. Pickering
JPL Director

ARS 1959 ASTRONAUTICAL EXPOSITION



MAIN EXHIBIT AREA



AUXILIARY EXHIBITION HALL

SECOND FLOOR EXHIBIT AREA

ARS AWARD WINNERS

S. K. Hoffman
Goddard Award

Walter Dornberger
Astronautics Award

Karel J. Bossart
Wyld Award

E. R. Roberts
Hickman Award

Ali B. Cambel
Pendray Award

MAN IN SPACE—DESIGN WORK TO DATE (Seminar)

8:00 p.m. **Sheraton Hall South**

Chairman: Lt. Col. Stanley White, Langley Research Center, Hampton, Va.

Vice-Chairman: William Turner, Wright Air Development Center, Wright-Patterson AFB, Ohio.

✦Should the Experiment Use Man as a Part of the Machine From the Start? Lt. Col. Stanley White, Langley Research Center, Hampton, Va., and William Turner, Wright Air Development Center, Wright-Patterson AFB, Ohio.

✦Measurement of Man's Performance in Space Vehicles from the Physical and Mental Approach, Richard Lawton, Missile and Space Vehicle Dept., General Electric Co., Philadelphia, Pa.

✦Man's Integration into the Machine as a Monitor and Primary Controller of the Vehicle, Fred A. Payne, North American Aviation, El Segundo, Calif.

✦Decisions Which Have Resulted in Man's Integration into Project Mercury Capsules (Author to be announced), McDonnell Aircraft Co., St. Louis, Mo.

Tuesday, November 17

SAFETY AND RELIABILITY OF LIQUID ROCKETS

9:00 a.m. **Sheraton Hall South**

Chairman: Albert G. Thatcher, Reaction Motors Div., Thiokol Chemical Corp., Denville, N. J.

Vice-Chairman: Charles Mraz, Aerojet-General Corp., Washington, D.C.

✦Propulsion Aspects of the Piloted Space Flight Safety Problem, James M. Madden, Aerojet-General Corp., Azusa, Calif. (950-59)

✦Evaluating Crew Safety for Rocket-Powered Manned Space Vehicles, W. L. Hadley, Bell Aircraft Co., Buffalo, N.Y. (951-59)

✦Performance and Reliability of Attitude Control Rocket Systems, O. S. Williams, Reaction Motors, Div., Thiokol Chemical Corp., Denville, N. J. (952-59)

✦Effects of Manned-Payloads on Booster Engine Requirements in Regard to Safety and Reliability, C. S. Kaplan, and J. P. Hynds, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif. (953-59)

ASTRODYNAMICS

9:00 a.m. **Continental Room**

Chairman: Samuel Herrick, Aeronutronic, A Div. of Ford Motor Co., Newport Beach, Calif.

Vice-Chairman: Simone Gossner, Naval Observatory, Washington, D. C.

✦Researches in Interplanetary Transfer, John V. Breakwell, Rollin W. Gillespie, and Stanley Ross, Lockheed Missiles and Space Div., Palo Alto, Calif. (954-59)

✦Thrust Orientation Patterns for Orbit Adjustment with Low Thrust Vehicles, Harold Brown and J. Richard Nelson, General Electric Co., Cincinnati, Ohio. (955-59)

✦Optimum Re-entry Via a Variable Control Force, F. J. Marshall, Univ. of Chicago, Chicago, Ill. (956-59)

✦Planetary Perturbations of Interplanetary Orbits, J. E. Michaels and E. A. Strawbridge, Missile and Space Vehicle Dept., General Electric Co., Philadelphia, Pa. (957-59)

✦Mechanics of the Power and Launching Phase for Missiles and Satellites, C. A. Traenkle, Wright Air Development Center, Wright-Patterson AFB, Ohio. (958-59)

✦Differential Correction Experimentation with the Low-Eccentricity Project Mercury Orbit, L. G. Walters, C. T. Van Sant, J. D. Enright, and L. Saskin, Aeronutronic, A Div. of Ford Motor Co., Newport Beach, Calif. (960-59)

FAR-SPACE COMMUNICATIONS TECHNIQUES

9:00 a.m. **Caribar Room**

Chairman: Robert Francisco, Missile and Space, Vehicle Dept., General Electric Co., Philadelphia, Pa.

Vice-Chairman: George Adair, George P. Adair Engineering Co., Washington, D.C.

✦Recent Developments in Communications for Missiles and Space Programs, D. Hoehman, Lockheed Missiles and Space Div., Sunnyvale, Calif. (961-59)

✦Re-entry H.F. Transmission Experiment, J. B. Duryea, E. F. Paski, and W. L. Aseniero, Missile and Space Vehicle Dept., General Electric Co., Philadelphia, Pa. (962-59)

✦Communications Through Re-Entry Blackout, Robert White, Research & Advanced Development Div., Avco Corp., Wilmington, Mass. (963-59)

(*Additional paper to be announced*)

SPACE LAW AND SOCIOLOGY

9:00 a.m. **Burgundy Room**

Chairman: Andrew G. Haley, General Counsel, American Rocket Society, Washington, D. C.

Vice-Chairman: Jiri Nehnevajsa, Columbia Univ., New York, N. Y.

✦Alterations in Cultural Patterns Resulting from the Developing Program of Astronautics, James S. Hanrahan, Air Force Missile Development Center, Holloman AFB, N. M. (964-59)

✦Possible Forthcoming Problems in the Social Psychology of Space Exploration, Donald N. Michael, Dunlap and Associates, Inc., Stamford, Conn. (965-59)

✦Astronautical and Space Industry of the Future, Emanuel Celler, U.S. House of Representatives, Washington, D.C. (966-59)

✦Establishing U.N. Sovereignty on the Frontier of Outer Space, Clark M. Eichelberger, American Assn. for the United Nations, Inc., New York, N.Y. (967-59)

✦Man in Space, Spencer M. Beresford, U.S. House of Representatives, Washington, D.C. (968-59)

✦Man in Space Means Men in Space: Some Consequences, Jiri Nehnevajsa, Columbia Univ., New York, N.Y. (969-59)

✦The Evolution of International Space Law, George J. Feldman, New York, N.Y. (970-59)

✦A Manufacturing Manager Looks at Space Law, Frank R. Swaney, Chrysler Corp., Detroit, Mich. (934-59)

✦The Activities of the United States Senate Committee on Aeronautical and Space Sciences in the Field of the Natural Sciences as Related to Astronautics, Warren G. Magnuson, U.S. Senate, Washington, D.C. (971-59)

✦Space Law—Retrospect and Promise, Andrew G. Haley, General Counsel, American Rocket Society, Washington, D.C. (972-59)

LUNCHEON

12:30 p.m. **Sheraton Hall North**

Toastmaster: Robert L. Hirsch, Manager, Washington Office, Aerojet-General Corporation, Washington, D.C.

Speaker: Brig. Gen. Homer A. Boushey, Director of Advanced Technology, Deputy Chief of Staff for Development, Hq., USAF.

SOLID ROCKET TECHNOLOGY

2:30 p.m. **Sheraton Hall South**

Chairman: Richard Winer, Allegany Ballistics Laboratory, Cumberland, Md.

Vice-Chairman: Arch Scurlock, Atlantic Research Corp., Alexandria, Va.

✦On the Use of Solid Propellants for Multi-Million Pound Boosters, John Gustavson, Grand Central Rocket Co., Redlands, Calif. (973-59)

✦Transition of Solid Propellant Rocket Motors from R&D to Production, R. A. McElvogue, Thiokol Chemical Corp., Longhorn Div., Marshall, Tex. (974-59)

✦Proximate Advances in Static Testing, William Pennington, Space Technology Laboratories, Inc., Los Angeles, Calif. (975-59)

✦Solid Propellant Information Agency Activities, Karl Ockert and G. S. MacMurray, Johns Hopkins Univ., Applied Physics Laboratory, Silver Spring, Md. (976-59)

✦Systems for the Ignition of Solid Propellant Rockets, J. Rabern, Olin Mathieson Chemical Corp., East Alton, Ill. (977-59)

✦Design Considerations for Spiralloy Glass Reinforced Filament Wound Structures as Rocket Inert Parts, C. C. DeHaven, Austin H. Kitzmiller, and Richard Young, Allegany Ballistics Laboratory, Cumberland, Md. (983-59)

SPACE COMMUNICATIONS EQUIPMENT

2:30 p.m. Continental Room

Chairman: Max Lowy, Data Control Systems, Inc., Danbury, Conn.

✦Abrupt Telemetry Signal Strength Fades in Powered Flight on WS107A Re-Entry Vehicles, E. Niemann, Jr., Missile and Space Vehicle Dept., General Electric Co., Philadelphia, Pa. (978-59)

✦Decommutation of 100% Duty Cycle Telemetered Signals, M. G. Pawley and E. D. Heberling, U.S. Naval Ordnance Laboratory, Corona, Calif. (979-59)

✦An Analog and Digital Airborne Data Acquisition System, James M. Walter and Donald H. Ellis, Radiation, Inc., Melbourne, Fla. (980-59)

✦A Comparison Between PDM/FM System Using Gaussian and Ideal Vertical Cutoff, Low-Pass Filter, Myron Nichols and Arthur Bubblitz, Univ. of Michigan, Ann Arbor, Mich. (981-59)

RAMJETS (Confidential)

2:30 p.m. Dept. of the Interior Auditorium

Chairman: W. H. Avery, Applied Physics Laboratory, The Johns Hopkins Univ., Silver Spring, Md.

Vice-Chairman: Maj. Joseph M. Du Bois, Air Research and Development Command, Washington, D.C.

✦Ramjet Power for Supersonic, Low Altitude Vehicles, Arthur N. Thomas, Marquardt Corp., Van Nuys, Calif.

✦Direct Flying Costs of Ramjet-Powered Airplanes, Robert A. Cornog, Ramo-Wooldridge Div., Thompson Ramo-Wooldridge, Inc., Hawthorne, Calif.

✦Performance of Liquid Fuel Ram-Rockets, E. C. Wilkerson and R. L. Wolf, Experiment, Inc., Richmond, Va.

✦Talos Ramjets, William B. Shippen, Applied Physics Laboratory, The Johns Hopkins Univ., Silver Spring, Md.

PHILOSOPHY OF EDUCATION—THE SCIENTIST AND ENGINEER AND THEIR ENVIRONMENT (Panel)

2:30 p.m. Burgundy Room

Chairman: T. Paul Torda, Arma Research Foundation, Chicago, Ill.

Vice-Chairman: Francis Hayden, Catholic Univ. of America, Washington, D.C.

The panel will aim to define the role and the place of the scientist and engineer in society, and to define his responsibilities in the socio-economic sense. The panel will explore the philosophy of education leading to the realization of these aims.

MARKETING SYMPOSIUM

3:30 p.m. Caribar Room

NATIONAL CAPITAL SECTION PROGRAM

8:00 p.m. Sheraton Hall South

A panel of leading representatives of the Army, Navy, and Air Force, Advanced Research Projects Agency, and National Aeronautics and Space Administration will discuss present activities and plans for the nation's space programs.

Wednesday, November 18

STRUCTURES AND MATERIALS IN NEAR SPACE

9:00 a.m. Caribar Room

Chairman: Frederick L. Bagby, Battelle Memorial Institute, Columbus, Ohio.

Vice-Chairman: Milton Rosen, National Aeronautics and Space Administration, Washington, D.C.

✦Simulation of Environmental Conditions in Near Space, John C. Simons, Jr., National Research Corp., Cambridge, Mass. (984-59)

✦Surface Behavior in Near Space, Francis Clauss, Lockheed Missiles and Space Div., Sunnyvale, Calif. (985-59)

✦Materials in Energy Conversion Systems, John M. Allen, Battelle Memorial Institute, Columbus, Ohio. (986-59)

✦Development of the Capsule Pressure Vessel for Project Mercury, Fred Sanders, McDonnell Aircraft Corp., St. Louis, Mo. (987-59)

CURRENT PROBLEMS OF SPACE TRAVEL

9:00 a.m. Burgundy Room

Chairman: Robert R. Gilruth, National Aeronautics and Space Administration, Langley Field, Va.

Vice-Chairman: Kurt Stehling, National Aeronautics and Space Administration, Washington, D.C.

✦Survival Equipment for Emergency Space Vehicle Abandonment, H. L. Bloom, Missile and Space Vehicles Dept., General Electric Co., Philadelphia, Pa. (988-59)

✦Radiation Problems in Low Thrust Space Travel, M. G. Del Duca, A. D. Babinsky, and Angus F. Bond, Tapco Group, Thompson Ramo-Wooldridge, Inc., Cleveland, Ohio. (989-59)

✦The Advantages of Low Thrust Space Vehicles, Ernst Stuhlinger, Army Ballistic Missile Agency, Redstone Arsenal, Alabama. (990-59)

✦Advantages of High Thrust Space Vehicles, Maxwell W. Hunter and J. M. Tschirgi, Douglas Aircraft Co., Santa Monica, Calif. (991-59)

TEST FACILITIES AND GROUND SUPPORT EQUIPMENT

9:00 a.m. Burgundy Room

Chairman: Richard F. Gompertz, Rocketdyne, North American Aviation, Canoga Park, Calif.

NEW ARS FELLOW MEMBERS

A. L. Antonio

William Avery

Kurt Berman

Maj. Gen. Ira Davis

Kurt Debus

R. D. Geckler

T. Keith Glennan

James J. Harford

R. M. Lawrence

NEW ARS FELLOW MEMBERS

Lester Lees

T. F. Morrow

W. T. Olson

William G. Purdy

R. B. Rees

Milton Rosen

Vice-Chairman: Robert Kendall, Arthur D. Little, Inc., Edwards AFB, California.

✦Missile and GSE Transportation Environment, M. T. Kirkenmeier, Chrysler Missile Div., Detroit, Mich. (993-59)

✦Support Equipment Designers Look at the Moon, M. J. Neder and T. E. Walsh, Aerojet-General Corp., Azusa, Calif. (994-59)

✦Ion Engine Test Laboratory Planning, R. O. Dietz, Arnold Engineering Development Center, Tullahoma, Tenn. (995-59)

✦Altitude Facility Rocket Testing, I. C. Lightner, Arnold Engineering Development Center, Tullahoma, Tenn. (996-59)

✦Are We Ready? Leonard Chevlin, The Martin Co., Denver, Colo. (997-59)

ADVANCES IN MINIATURIZATION

9:00 a.m. Continental Room

Chairman: Louis B. Forman, Chrysler Corp., Detroit, Mich.

Vice-Chairman: Peter Hagen, National Aeronautics and Space Administration, Washington, D.C.

✦Microminiaturization of Space Computers, Elise F. Harmon and Edward Keonjian, American Bosch Arma Corp., Hempstead, N.Y. (998-59)

✦Macro-Modual Program, Stanley Schneider, Burroughs Corp., Paoli, Pa. (999-59)

✦Semiconductor Solid Circuits, J. S. Kelby, Texas Instruments, Inc., Dallas, Tex. (1000-59)

✦Molecular Engineering, Jean Struhl, Westinghouse Air Arm Div., Baltimore, Md. (1001-59)

✦Data Recovery—The Heart of the Flight Instrumentation Problem, P. A. Laethrop, Missile and Space Vehicles Dept., General Electric Co., Philadelphia, Pa. (1003-59)

SURVEY OF STORABLE PROPELLANTS AND COMBUSTION OSCILLATIONS (Confidential)

9:30 a.m. Dept. of the Interior Auditorium

Chairman: John L. Sloop, National Aeronautics and Space Administration, Cleveland, Ohio.

Vice-Chairman: James R. Patton, Office of Naval Research, Washington, D.C.

✦Introductory Remarks, John L. Sloop, National Aeronautics and Space Administration, Cleveland, Ohio.

✦Recent Progress in Solid Propellants, Allen R. Deschere, Rohm & Haas Co., Huntsville, Ala.

✦Performance, Properties, and Combustion Characteristics of Advanced Storable Propellants, Stanley Lehrer, Reaction Motors Div., Thiokol Chemical Corp., Denville, N. J.

✦Understanding and Attenuating Combustion Oscillation, Robert S. Levine, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif.

LUNCHEON

12:30 p.m. Sheraton Hall North

Toastmaster: John D. Gilchrist, Director, Customer Relations District Offices, Aerojet-General Corp., Washington, D.C.

Speaker: William H. Pickering, Director, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, Calif.

PLASMA PROPULSION

2:30 p.m. Burgundy Room

Chairman: Mark L. Ghai, General Electric Co., Cincinnati, Ohio.

Vice-Chairman: W. C. Cooley, National Aeronautics and Space Administration, Washington, D.C.

✦Plasma Jet Applications for Spaceflight, Gerhard Heller, Army Ballistic Missile Agency, Huntsville, Ala. (1004-59)

✦NASA Research on Plasma Propulsion, W. Moeckel and W. Rayle, Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio. (1005-59)

✦Plasma Generation for Electrothermal Propulsion and Electromagnetic Propulsion Systems, F. Martinek and B. Harned, Flight Propulsion Laboratory Dept., General Electric Co., Cincinnati, Ohio. (1006-59)

✦Magnetohydrodynamic Flow Experiments of a Steady State Nature, V. H. Blackman, MHD Research, Inc., Newport Beach, Calif. (1007-59)

✦Experimental Results with a Collinear Electrode Plasma Accelerator and a Comparison with Ion Accelerators, S. W. Kash and W. L. Starr, Lockheed Aircraft Corp., Sunnyvale, Calif. (1008-59)

✦On Magnetohydrodynamic Propulsion, Arthur Kantrowitz and G. S. Janes, Avco-Everett Research Laboratory, Everett, Mass. (1009-59)

✦Plasma Propulsion, Gordon L. Cann and Adriano C. Ducati, Giannini Plasmadyne Corp., Pasadena, Calif. (1010-59)

RECOVERABLE BOOSTER

2:30 p.m. Sheraton Hall South

Chairman: A. L. Shef, Advanced Research Projects Agency, Washington, D.C.

✦The Economy of Recoverable Two-Stage Orbital Carrier Vehicles, H. H. Koelle, Army Ballistic Missile Agency, Huntsville, Ala. (1011-59)

✦Recoverable Boosters—The Next Big Step in Satellite and Space Systems, R. P. Buschmann, Lockheed Aircraft Corp., Palo Alto, Calif. (1012-59)

✦Winged Recoverable Booster Characteristics, Frank J. Dore, Convair-Astronautics, San Diego, Calif. (1013-59)

✦Recoverable Booster. Panel discussion with above authors, with A. S. Donovan, Space Technology Laboratories, Los Angeles, Calif., panel moderator.

PAYLOAD INSTRUMENTATION

2:30 p.m. Continental Room

Chairman: Herbert Friedman, Naval Research Laboratory, Washington, D.C.

✦Instrumentation for Measuring the Structural Parameters of the Upper Atmosphere, Leslie M. Jones, Univ. of Michigan, Ann Arbor, Mich. (1015-59)

✦Aspect Sensing, Astrostat Design and Orientation Control in Space Research, Russell A. Nidey, Kitt Peak National Observatory, Tucson, Ariz. (1016-59)

✦Atomic Clocks for Satellite Experiments, Peter L. Bender, National Bureau of Standards, Washington, D.C. (1017-59)

✦Instrumentation for Space Magnetic Field Studies, James P. Heppner, National Aeronautics and Space Administration, Washington, D.C. (1018-59)

✦Redstone, Jupiter, Saturn: Evolution of a Measuring System, C. T. N. Paludan, Army Ballistic Missile Agency, Redstone Arsenal, Ala. (1020-59)

LIQUID ROCKETS (Confidential)

2:30 p.m. Dept. of the Interior Auditorium

Chairman: Frank Goddard, Jet Propulsion Laboratory, Pasadena, Calif.

Vice-Chairman: Ralph Kauffman, Bureau of Aeronautics, Washington, D.C.

✦High Discharge Pressure Hydrogen Pumps, J. C. Moise, W. W. Heath, and E. Eber, Aerojet-General Corp., Azusa, Calif.

✦Safety and Reliability for Manned Space Flight, G. R. Cramer and H. A. Barton Reaction Motors Div., Thiokol Chemical Corp., Denville, N.J.

✦Development of a 6000-Pound Thrust Nitrogen Tetroxide Hydrazine Propulsion System, J. D. McKenney, Jet Propulsion Laboratory, Pasadena, Calif.

✦Some Considerations of Single or Multiple Chamber Booster Applications, F. Iacobellis, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif.

✦Flow Characteristics and Performance of Cluster Rocket Exhausts at High Altitudes B. H. Goethert, ARO, Inc., Arnold Engineering Development Center, Tullahoma, Tenn.

RECEPTION

6:00 p.m. Continental Room

Auspices of Aerojet-General Corp.

(For those holding banquet tickets)

HONORS NIGHT DINNER

7:00 p.m. Sheraton Hall

Presiding: Col. John P. Stapp, President, American Rocket Society.

ARS SECTIONS AND STUDENT CHAPTERS

Section and President

1. Alabama—R. D. Stewart
2. Antelope Valley—R. J. Harer
3. Central California—R. F. Freitag (Acting)
4. Central Colorado—D. M. Cole
5. Central Indiana—T. F. Nagey
6. Central New York—R. S. Grisetti
7. Central Texas—W. G. Haymes
8. Chicago—C. C. Miesse
9. Cleveland-Akron—H. W. Douglass
10. Columbus—E. W. Smith
11. Connecticut Valley—C. W. Lemmerman
12. Dayton—R. W. Clarke
13. Delaware—H. I. Bomar Jr.
14. Detroit—E. A. Nielsen
15. Florida—B. G. MacNabb
16. Ft. Wayne—F. H. Brady
17. Holloman—Knox Millsaps
18. Houston—Larry Megow (Acting)
19. Indiana—A. C. Pinchak
20. Kansas City—A. R. Pittaway
21. Long Island—Abelardo de Alcala
22. Maryland—H. J. Hasenfus
23. National Capital—W. H. Roennau (Acting)
24. Neosho—W. J. Baisley
25. New England—John Harvell
26. New Mexico-West Texas—Lew Byrd
27. New York—R. P. Frazee
28. Niagara Frontier—Clayton Williams
29. Northeastern New York—N. E. Munch
30. Northern California—J. S. Arnold
31. North Texas—J. A. Kerr
32. Orlando—Richard Krauss (Acting)
33. Pacific Northwest—G. W. Hettrick
34. Palm Beach—H. J. Barten
35. Philadelphia—J. E. Walton
36. Pittsburgh—E. R. Arnold
37. Princeton—Jerry Grey (Acting)
38. Rock River—F. M. Johnson
39. Sacramento—D. F. Sprenger
40. St. Joseph Valley—R. E. Defrees
41. St. Louis—James N. Holsen
42. San Diego—C. L. Bates
43. Southern California—W. J. Cecka Jr.
44. Southern Ohio—Lou Michelson
45. Southwestern Michigan—W. J. Lator (Acting)
46. Tennessee—H. M. Cook
47. Twin Cities—Rudolf Hermann
48. University Park—J. D. Decker
49. Utah—C. S. Roberts Jr.
50. Valley Forge—W. L. Doyle
51. Wichita—Alex Petroff

Student Chapter and Presidents

A. Academy of Aeronautics—Alfred E. Toombs
B. Alabama Polytechnic Institute—Axel Roth
C. Boston University—Walter Kimball
D. California State Polytechnic College—Philip A. Bohm
E. University of California—Donald Christenson
F. City College of New York—Alvin B. Blacksburg
G. University of Colorado—James Dillow
H. University of Connecticut—Alan Kessler
I. Drexel Institute of Technology—Thomas J. Hayes
J. Fairleigh Dickinson University—Peter J. Wank
K. Fenn College—Allan J. Smith Jr.
L. University of Florida—Jack Bodne
M. Georgia Institute of Technology—Henry Hillbrath
N. University of Hartford—Joseph Brown
O. Marquette University—John Aschenbrener
P. Massachusetts Institute of Technology—Robert Esterling
Q. University of Miami—Robert Rosen
R. University of Michigan—Erle H. Wales
S. University of Minnesota—Jerome Blanz
T. University of Missouri—Susan Lette (Secretary)
U. Newark College of Engineering—Dave Broome
V. U.S. Naval Postgraduate School—Thomas C. Warren
W. New York University—Harris Weingold
X. University of Oklahoma—Elton Thompson
Y. Polytechnic Institute of Brooklyn—Arthur C. Martinez
Z. Rensselaer Polytechnic Institute—Thomy Nilsson
AA. St. Ambrose College—Nicholas Kass
BB. St. Louis University—Parks College of Aeronautical Technology—Stephen Koob
CC. Stevens Institute of Technology—Alfred H. Filskov
DD. University of Texas—Ettore Infante
EE. Tri-State College—B. L. Twitty (Faculty Sponsor)
FF. Vanderbilt University—V. W. Gerth Jr.
GG. University of Virginia—H. Duane Evans
HH. University of Washington—Donald L. Ciffone
II. Wayne State University—James Wells

Speaker: John A. McCone, Chairman, Atomic Energy Commission, on "The Influence of Nuclear Technology on Rockets and Space."

Award Presentations: Robert H. Goddard Memorial Award, C. N. Hickman Award, G. Edward Pendray Award, James H. Wyld Memorial Award, ARS Astronautics Award, ARS Chrysler Corp. Student Award, ARS Thiokol Award, and Fellow Member announcements.

Thursday, November 19

SPACE LAW AND SOCIOLOGY

9:00 a.m. **Continental Room**

Chairman: Harold W. Saunders, State Univ. of Iowa, Iowa City, Iowa.

Vice-Chairman: Ralph E. Becker, Brookhart, Becker & Dorsey, Washington, D.C.

✦Satellites—A Force for World Peace, Eilene Galloway, U.S. Senate, Washington, D.C. (1023-59)

✦Rocket to Space, Peter W. Rodino, Jr., U.S. House of Representatives, Washington, D.C. (1025-59)

✦Social Influences on Power Technology, William C. Lawton, Univ. of Arizona, Tucson, Ariz. (1026-59)

✦Radio Frequency Control for the Space Age, Howard W. Cannon, U.S. Senate, Washington, D.C. (1027-59)

✦Is it Time for a Space Law Code? Leo Albert Huard, Georgetown Univ. Law Center, Washington, D.C. (1028-59)

✦Public Understanding and the Need for Space Laws, Emilio Q. Daddario, U.S. House of Representatives, Washington, D. C. (1029-59)

✦A Suggested Frame of Reference for Sociological Research on Outer Space, Harold W. Saunders, State Univ. of Iowa, Iowa City, Iowa. (1030-59)

✦The Impact of Space Technology on Medical Research, David Bushnell, Air Research & Development Command, Holloman AFB, N.M. (1031-59)

✦World Peace Through Space Law, William A. Hyman, Hyman, Hayman & Harris, New York, N.Y. (1022-59)

POWER SYSTEMS

9:00 a.m. **Sheraton Hall South**

Chairman: B. J. Wilson, Naval Research Laboratory, Washington, D.C.

Vice-Chairman: Maj. William G. Alexander, Air Research and Development Command, Washington, D.C.

✦Available Power System for Space Vehicles, Harris J. Howard and Robert W. McJones, Vickers, Inc., Torrance, Calif. (1032-59)

✦The Advanced Sterling Engine for Satellite and Space Secondary Power, H. W. Welsh, E. A. Poste, and R. B. Wright, Allison Div., General Motors Corp., Indianapolis, Ind. (1033-59)

✦Engineering Calculations of Thermoelectric Machines: A Topological Presentation, Irving Sochard, Diamond Ordnance Fuze Laboratory, Washington, D.C. (1034-59)

✦A Method of Predicting Chemical APU Performances Through Use of Rocket Parameters, Paul C. Juhasy, Boeing Airplane Co., Seattle, Wash. (1036-59)

✦The Modular Concept Applied to Secondary Power Supplies, J. A. Meyer and E. Barrett, Boeing Airplane Co., Seattle, Wash. (1037-59)

RECENT ADVANCES IN NUCLEAR PROPULSION
(Secret—Restricted Data)

9:30 a.m. **Dept. of the Interior Auditorium**

Chairman: Lt. Col. Howard Schmidt, Atomic Energy Commission, Germantown, Md.

Vice-Chairman: Harry Finger, National Aeronautics and Space Administration, Washington, D.C.

✦Nuclear Rocket Fuel Technology, J. M. Taub, Los Alamos Scientific Laboratory of the Univ. of California, Los Alamos, N.M.

✦Graphite Corrosion Kinetics, J. D. Rogers, D. Clifton, A. Gonzales, and A. Sesonske, Los Alamos Scientific Laboratory of the Univ. of California, Los Alamos, N.M.

✦Kiwi-A Design Details, F. P. Durham, Los Alamos Scientific Laboratory of the Univ. of California, Los Alamos, N.M.

✦Kiwi-A Testing, R. W. Spence, Los Alamos Scientific Laboratory of the Univ. of California, Los Alamos, N.M.

POWER SYSTEMS

2:30 p.m. **Sheraton Hall South**

Chairman: B. J. Wilson, Naval Research Laboratory, Washington, D.C.

Vice-Chairman: Maj. William G. Alexander, Air Research and Development Command, Washington, D.C.

✦Approaches to the Ultimate in Solar Heat-to-Electricity Conversion, Thomas Timar, Boeing Airplane Co., Seattle, Wash. (1038-59)

✦Regenerative Fuel Cells as Auxiliary Power Supplies for Space Vehicles, M. G. Del Duca, J. M. Fuscoe, and T. A. Johnston, Thompson Ramo Wooldridge, Inc., Cleveland, Ohio. (1039-59)

✦Why a Space Power Station? I. J. Adleson, Sundstrand Turbo Div., Denver, Colo. (1040-59)

✦A Heat Storage System for Satellite Power Plants, C. L. Walker, J. D. Matchett, and R. J. Hanold, Allison Div., General Motors Corp., Indianapolis, Ind. (1041-59)

✦Basic Energy Conversion in Space Vehicles, James H. Fisher and Charles W. Stephens, Electro-Optical Systems, Inc., Pasadena, Calif. (1042-59)

RECENT ADVANCES IN NUCLEAR PROPULSION (Secret—Restricted Data)

2:30 p.m. **Dept of the Interior Auditorium**

Chairman: Lt. Col. Howard Schmidt, Atomic Energy Commission, Germantown, Md.

Vice-Chairman: Harry Finger, National Aeronautics and Space Administration, Washington, D.C.

✦High Temperature Critical Systems, Harry L. Reynolds, Univ. of California, Lawrence Radiation Laboratory, Livermore, Calif.

✦Thermofracture in BeO Fuel Elements, Robert B. Meuser, University of California, Lawrence Radiation Laboratory, Livermore, Calif.

(Additional papers to be announced)

LADIES PROGRAM

Tuesday, November 17

Tour #1 **10:30 a.m.**

Mt. Vernon, Alexandria, and Arlington

Tour of Mt. Vernon, Alexandria, and Arlington. Time approximately 5½ hours. Stop at Lincoln Memorial, tour of Arlington Cemetry, stop for Changing of the Guard at the Tomb of the Unknown Soldier, stop at Iwo Jima Memorial, tour of historic Alexandria, stop at Christ Church, scenic route to Mt. Vernon via George Washington Memorial Parkway, tour of restored Mansion and Plantation at Mt. Vernon, view on return route Pentagon, Jefferson Memorial, and Tidal Basin. Luncheon at Hogates Seafood Restaurant.

Complete Cost: $7.25

Wednesday, November 18

Tour #2 **11:30 a.m.**

Fashion Show

Transportation to and from hotel for luncheon and fashion show in Tea Room at Garfinckel's. Luncheon a la Carte.

Transportation: $1.00

Thursday, November 19

Tour #3 **10:00 a.m.**

Public Buildings, Embassies, and Churches

Approximately 5½ hours. Guided tour of White House and U.S. Capitol Building,riding tour of downtown Washington, Government Buildings area, Federal Triangle viewing enroute Museums, National Gallery of Art, Washington Monument, etc., riding tour through Old Georgetown viewing enroute C & O Canal, the old Seaport, quaint fashion shops, Dunbarton House, Georgetown University, riding tour of Embassy Row and fashionable residential area of Kalorama Heights, stopping enroute at the Islamic Mosque, Washington National Cathedral, luncheon at the Washington Hotel Sky Room.

Complete Cost: $7.50

NEW ARS FELLOW MEMBERS

Raemer Schreiber

John I. Shafer

Kurt Stehling

Homer J. Stewart

James Van Allen

David Young

The technical program: A look ahead

Growth of ARS in past few years is indicated by a mammoth program which includes 29 technical sessions and 105 unclassified papers

By Irwin Hersey

THE IMPRESSIVE GROWTH of ARS during the past few years has never been more clearly delineated than in the technical program for the 14th Annual Meeting in Washington, D.C., this month.

For, under the able leadership of Brooks Morris, national program chairman, and the chairmen of the 22 ARS Technical Committees, the biggest and best technical program ever to mark a Society meeting has been put together. It includes 29 sessions, five of which are classified (two Secret and three Confidential), and some 105 unclassified papers, encompassing virtually every facet of ARS activity and interest, and ranging all the way from space law and sociology to nuclear propulsion.

Marked by Several "Firsts"

The technical program for the meeting is marked by a number of "firsts," not the least of which is the fact that the large number of sessions planned (almost double the 16 at last year's annual meeting) has necessitated quadruple sessions in some instances, and even one quintuple session.

Sessions on guidance, gas wave phenomena, and physics of the atmosphere and space will open the technical program on Monday morning, Nov. 16. The guidance session promises to be of unusual interest, since it will be marked by papers dealing with an orbiting astronomical telescope, guidance requirements for Mars and Venus probes, and satellite position-sensing methods.

Afternoon sessions the same day turn the spotlight on ion propulsion, space-vehicle bio-instrumentation, and propellants and combustion. The ion-propulsion session will produce two papers dealing with experimental work and two theoretical papers —one on physics of the ion-thrust system and the other on thrust multiplication by successive acceleration in ion systems. The bio-instrumentation session will be highlighted by a panel discussion on future requirements for improved bio-instrumentation techniques. Of interest in the propellants and combustion session are papers dealing with metal combustion processes and with liquid ozone as a rocket propellant.

A special Monday evening seminar will be devoted to design work done to date on man in space. Among the interesting topics to be discussed are the question of whether man should be part of the machine from the start; measuring man's performance in a space vehicle; integration of man into the machine as a monitor and primary controller of the vehicle; and decisions which have resulted in integration of man into the Project Mercury capsule.

Tuesday morning brings the first quadruple sessions, dealing with liquid rocket safety and reliability, astrodynamics, far-space communications techniques, and space law and sociology. The liquid rocket session will highlight propulsion aspects of the manned spaceflight safety problem, effects of manned payloads on booster requirements, and performance and reliability of rocket attitude-control systems. Among the topics to be covered in the astrodynamics session are interplanetary transfers, optimum re-entry via a variable control force, and planetary perturbations of interplanetary orbits.

Major Space Session Planned

The mammoth space law and sociology session, first of two at the meeting, will be marked by the presentation of 10 short papers, including two by members of Congress, Rep. Emanuel Celler (D., N.Y.) and Sen. Warren Magnuson (D., Wash.). Gen. Clark M. Eichelberger, now with the American Assn. for the UN, is also scheduled to present a paper.

Quadruple sessions the same afternoon will see discussions of solid rocket technology, space communications equipment, and ramjets (on the Confidential level), and a panel discussion on the philosophy of education. The solid rocket session will include papers on the use of solid propellants in multimillion-pound (CONTINUED ON PAGE 152)

East and West Meet at IAF Congress

The alphabet seated East and West next to each other at the IAF Congress in London in September. Left to right: IAF president-elect Leonid I. Sedov and Prof. K. Ogorodnikov of the Russian delegation; ARS President John P. Stapp and Board Member Martin Summerfield, who headed the ARS delegation; Robert P. Haviland of the AAS delegation; and Fred Singer. IAF is the sole international astronautical body in which the U.S.S.R. is still active.

International Scene

(CONTINUED FROM PAGE 20)

In May and June 1958, as the IAF's representative, I actively participated in the sessions of CCIR Study Group XI meeting in Moscow. Study Group XI concerned itself with the subject of television, and a specific Study Question on the agenda was related to television transmission over extremely long distances.

Accordingly, there were submitted for the consideration of Study Group XI three draft Study Questions and a proposed addition to Study Programme No. 32 (XI) of the CCIR to deal with general requirements for a 405 line 2000 kc/s video band system. These Study Questions dealt with the following subjects:

1. What practicable measures can be taken to provide for the transmission of television signals in connection with activities in astronautics?

2. How can the various uses of such transmission of television signals be categorized?

3. What are the requirements as to definition, frame rate, field rate, and other parameters for signals for the various categories of use?

4. How can standardization be effected which will promote the best international usage of such signals and the most efficient and useful employment of communications, telemetry, and guidance by means of such signals?

5. For the transmission of television signals over extremely long distances between earth and positions and objects in space:

A. What are the characteristics of the signal, circuitry, and propagation paths that must be considered? What are their recommended values? And what tolerances must be imposed in order to ensure satisfactory transmission?

B. How do these characteristics and their values and tolerances differ as between the requirements for the transmission of monochrome signals and color signals?

C. What methods of measurement and what test signals can be recommended for checking these characteristics?

* * *

Study Group VI of the CCIR met at Geneva in July and August 1958, and at this meeting the IAF submitted a lengthy proposal for consideration. The IAF proposal was twofold. First, a study of technical requirements was outlined which included the following subjects:

1. What frequencies are specially suitable for penetration of the layers of the earth's atmosphere?

2. What are the influences on these frequencies of the hour of the day, the season, the geographical location, and solar activity?

3. What deviations in propagation direction can be expected by the penetration of the ionosphere?

4. What, if any, will be the differences in propagation between ingoing and outgoing signals relative to the earth?

5. Are special phenomena to be expected that do not occur in transmission between two points on earth?

6. What is the possible influence of the troposphere on wave propagation to and from extraterrestrial objects?

Second, a thorough review of the then-known frequency allocation needs of astronautical radio services was made. Each of the portions of the radio spectrum was analyzed both as to the manner in which it was essential to astronautical radio service and as to the effects of any re-allocation thereof on existing users.

* * *

Following the Geneva meeting of the CCIR Study Group, the IAF commenced its preparation for two major conferences scheduled for 1959. These were the Ninth Plenary Assembly of the CCIR at Los Angeles in April and the administrative Radio Conference at Geneva from August to December.

As background for the CCIR Plenary Assembly in Los Angeles, the IAF supplied to the more than 950 delegates copies of the ARS Comments prepared in anticipation of the Geneva Conference, and copies of the direct testimony of a score of technical experts given under ARS auspices to the FCC in connection with the Commission's over-all frequency allocation hearing.

The Assembly proceeded to reorganize its Study Groups by merging Study Group IV (Ground-Wave Propagation) into Study Group V (Tropospheric Propagation), so that the new Study Group V deals with Propagation, Including the Effects of the Earth and Troposphere.

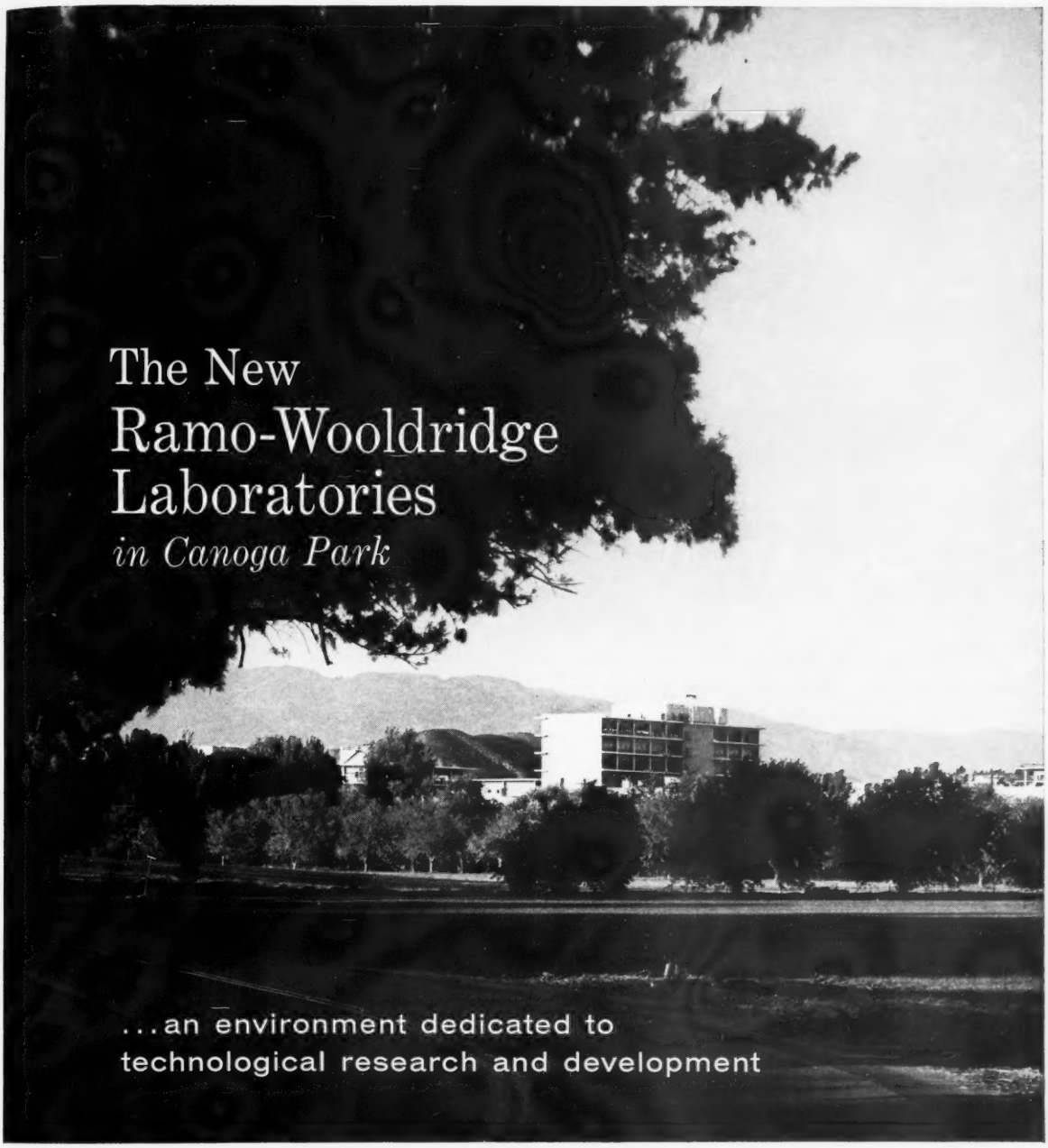
The new Study Group IV (Space Systems) was formed "to study systems of telecommunications with and between locations in space."

On July 14, 1959, in response to the request of the IAF, the CCIR formally included the IAF as a participant in this new Study Group on Space Communications.

* * *

As of this writing, the Geneva Radio Conference has been in session for more than two months. Several proposals for the allocation of radio frequencies for astronautical communications and research have been submitted for study. These are, in addition to the ARS-IAF proposal (discussed in this column in the March and April issues), other U.S. proposals, a United Kingdom proposal, and a COSPAR proposal.

There does not appear to be any substantial conflict between the various proposals which have been submitted to date, and it is to be hoped that, by the time the Conference is concluded late this year, concrete steps will have been taken to assure allocation of certain radio frequencies for earth-space and space use.



The new Ramo-Wooldridge Laboratories in Canoga Park, California, will provide an excellent environment for scientists and engineers engaged in technological research and development. Because of the high degree of scientific and engineering effort involved in Ramo-Wooldridge programs, technically trained people are assigned a more dominant role in the management of the organization than is customary.

The ninety-acre landscaped site, with modern buildings grouped around a central mall, contributes to the academic environment necessary for creative work. The new Laboratories will be the West Coast headquarters of Thompson Ramo Wooldridge Inc. as well as house the Ramo-Wooldridge division of TRW.

The Ramo-Wooldridge Laboratories are engaged in the broad fields of electronic systems technology, computers, and data processing. Outstanding opportunities exist for scientists and engineers.

For specific information on current openings write to Mr. D. L. Pyke.

THE RAMO-WOOLDRIDGE LABORATORIES

8433 FALLBROOK AVENUE, CANOGA PARK, CALIFORNIA

ARS news

Alabama Section Visits Arnold Engineering Center

The Alabama Section toured the Air Force's Arnold Engineering Development Center, Tullahoma, Tenn., recently as guests of the Tennessee Section. Above, members of the party—from left, Rodney Stewart, Alabama Section president; James Harford, ARS executive secretary on hand for the occasion; Mary Smith and Peggy Weems of Thiokol; and Harvey Cook, president of the host Tennessee Section—look at model of Arnold's wind-tunnel complex.

American Rocket Society

500 Fifth Avenue, New York 36, N. Y.

Founded 1930

OFFICERS

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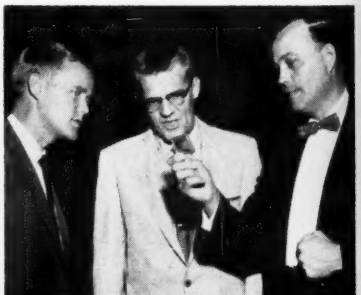
Proposed Arrowhead Section

Until recently, ARS members in San Bernardino and Riverside Counties, Calif., have had to travel for more than three hours to attend technical meetings in Los Angeles. For this and other reasons, a new ARS Section has been proposed for the area. Interested members are already active with informal meetings and a membership drive. The proposed Section counts more than 60 members slated presently, and is expected to reach the first hundred before a charter meeting planned for early 1960.

The acting officers of the Arrowhead Section are John Gustavson, Grand Central Rocket Co., president; Louis Crider, Norton AFB, vice-president; Ralph Pierce, Grand Central Rocket, secretary; and J. Schmidt, Western Fluidyne, treasurer.

The first technical meeting was held in August. Norman V. Petersen, chief of astronautics at Norair, spoke on "Space Training Devices for Earth Satellite and Moon Operations," describing the performance characteristics for inexpensive, rocket-powered, balloon-launched space-training capsules, and techniques for directing a capsule to a complete standstill at various points above the earth's atmosphere, so that space-station operations and landings on the moon can be simulated.



At right, N. V. Petersen discusses moonlanding technique with John Gustavson (left), acting president, and Louis Crider, acting vice-president, of the proposed ARS Arrowhead Section in California during the group's first meeting.

ARS Section for Long Island

ARS President John P. Stapp recently presented a charter to the newly formed Nassau-Suffolk Section of the Society at the Town House in

Our guard is up

...here too

Threats from the quiet reaches of space can now be considered *potential* threats . . . and defense against them a necessity. Raytheon Company's Missile Systems Division is already far into this vital defense program. Working with concepts far in advance of those which govern the SPARROW III and HAWK, Raytheon engineers are mixing imagination with talent . . . constantly probing, analyzing, modifying. Working in an environment where the creative mind has *room* to think, these men are facing the future *today* . . . solving tomorrow's defense problems *now*.

Raytheon has room for more such men in all of the following fields: OPERATIONS ANALYSIS • MICROWAVE • RADAR SYSTEMS • DATA PROCESSING • SYSTEMS ANALYSIS • PACKAGING • TUBE TECHNOLOGY.

These are positions in the nation's only electronics company with prime contracts for two major missile systems . . . an organization growing at a fabulous rate. They offer fine living conditions too . . . in New England, only minutes from Boston's unsurpassed educational facilities. Modern company benefits and relocation assistance.

Your resume will receive prompt attention. Please address it to: Mr. Richard K. Malcolm, Coordinator of Employment, Missile Systems Division, Raytheon Company, 520 Winter Street, Waltham, Mass.

RAYTHEON MISSILE SYSTEMS DIVISION

Huntington. The new Section was organized to provide improved services for the great number of engineers and scientists employed in the field of astronautics on Long Island. Plans are now being formulated for membership, technical meetings, committee activities, and educational programs. Programs will consist of lectures, films, symposiums, roundtable discussions, and field trips.

In addition to presenting the charter, Col. Stapp, Chief of WADC's Aeromedical Laboratory, discussed the development of space capsules and the results of the Air Force Man High project.

Gold Medal for Goddard

President Eisenhower signed a bill in mid-September authorizing issuance of a special gold medal to the late Dr. Robert H. Goddard in recognition of his pioneering achievements in rocket research.

Propellent Conference Proceedings Put Off

Labor difficulties at the Ohio State Univ. print shop have resulted in postponement of publication of the ARS Propellant Thermodynamics and Handling Conference until January. The volume, now expected to be some 350–400 pages long, is still available at the original price of $2.50, and may be ordered from the Ohio State Univ. Engineering Experiment Station, 156 West 19th Ave., Columbus 10, Ohio. Checks should be made payable to Ohio State Univ.

ARS Holds Workshop On Youth Program

An ARS Youth Program Workshop was held at Princeton Univ., Sept. 25–26. The meeting, chaired by J. Preston Layton, ARS National Board Member and vice-chairman of the ARS Membership Committee, was attended by representatives of a number of ARS Sections which have been active in youth work, the Boy Scouts of America, the U. S. Department of Health, Education and Welfare, and the ARS national headquarters staff.

In the course of the two-day meeting, the group produced a proposed ARS Youth Program which will be presented to the National Board at its meeting in Washington, D.C., this month.

1960 ARS Meeting Schedule

Date	Meeting	Location	Abstract Deadline
Jan. 28–29	Solid Propellants Conference	Princeton Univ.	Past
March 23–25	Ground Support Equipment Conference	Detroit, Mich.	Past
April 6–8	Structures and Materials Conference	Santa Barbara, Calif.	Dec. 15
May 9–12	ARS Semi-Annual Meeting and Astronautical Exposition	Los Angeles, Calif.	Jan. 18
May 23–25	National Telemetering Conference	Santa Monica, Calif.	Feb. 1
Aug. 15–20	11th International Astronautical Congress	Stockholm, Sweden	April 15
Dec. 5–8	ARS Annual Meeting and Astronautical Exposition	Washington, D.C.	Aug. 25

Send all abstracts to Meetings Manager, ARS, 500 Fifth Ave., New York 36, N.Y.

A Tourist's View of Russia

Richard D. Geckler, Aerojet-General vice-president, described his impressions of Russia to a recent meeting of the Sacramento Section. Flanking him above are L. J. Bornstein (left) and C. M. Beighley (right), vice-president and past-president, respectively, of the Sacramento Section.

Three More Companies Become ARS Members

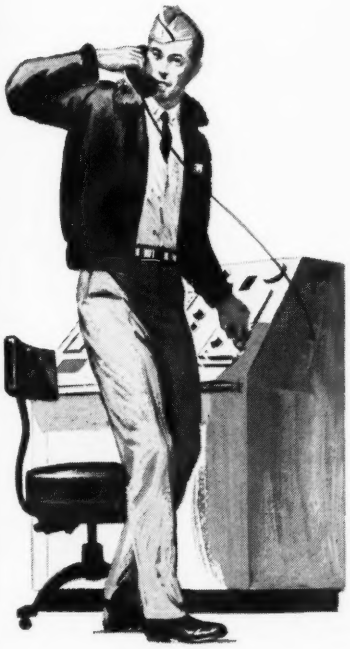
Three more companies have become corporate members of the AMERICAN ROCKET SOCIETY. The companies, their areas of activity, and those named to represent them in Society activities are:

Aeroscience, Inc., Rosemead, Calif., engaged in design and fabrication of rocket test facilities, load cells, pressure transducers, ground test equipment, and precision instruments. Representing the company in ARS are Joseph F. Ganahl, president; A. Newman Ormond, vice-president, research and development; Thurlow M. Morrow, director, special products; Shirrel R. Young, director, design; Charles P. Kries, executive vice-president; and Arthur R. McCarthy, design engineer.

The Budd Company, Philadelphia, Pa., engaged in development and manufacture of advanced missile and space-vehicle structures and functional elements handling equipment; metallurgical and welding research; and experimental testing techniques including environmental simulation. Named to represent the company in ARS are J. H. Buck, vice-president and general manager, Tatnall Measuring System Co., and the Nuclear Systems Div.; John B. Darrah, vice-president and general manager, Defense Div.; William H. Knowles Jr., sales manager, Defense Div.; H. D. VanSciver II, director of research; and E. R. Wisner, manager, military product sales, Railway Div.

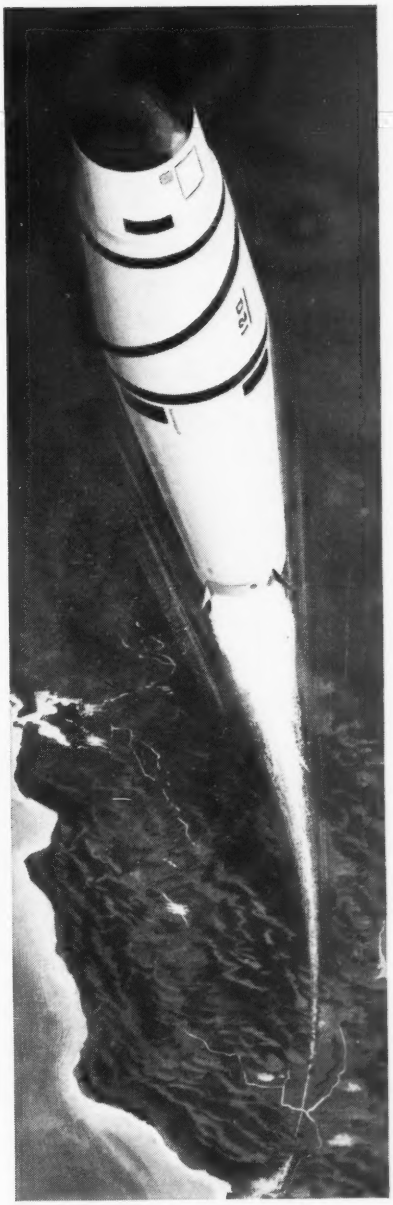
Minneapolis-Honeywell Regulator Co., Military Products Group, Minne-

SAC INTERMEDIATE RANGE BALLISTIC MISSILE



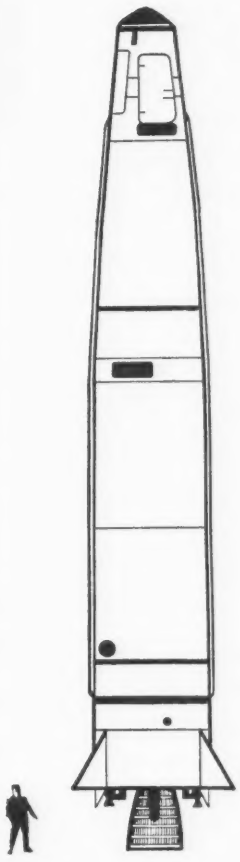
The man:

. . . a launch-control specialist in a *Thor* SAC squadron. His instruments report each automatic step in the launching procedure of the big IRBM. U.S. Air Force and Royal Air Force missilemen are receiving *Thor* training side-by-side . . . have readied and fired these missiles within a 20-minute count-down.



The missions:

. . . are many—because of the Douglas *Thor's* versatility. As a highly mobile weapon with atomic capability, it sternly warns potential enemies against aggression. As a powerful and reliable booster, it is playing a leading role in our exploration of outer space with satellites and probes.



The missile:

. . . can destroy targets as far as 1500 miles away within minutes after hostile action is detected. Douglas *Thor* missiles were the first intermediate range ballistic missiles to be deployed overseas. The United Kingdom has announced the delivery of the first *Thors*, for operation by Royal Air Force personnel.

Depend on **DOUGLAS**

The Nation's Partner in Defense

apolis, Minn., designs and manufactures components and systems for aircraft and missile fabrication, including automatic flight control systems, inertial guidance, and related instrumentation and control systems. Representing the company in ARS are Elden H. Olson, director of aeronautical engineering, Aeronautical Div.; Welsey O. Gerboth, project supervisor, special weapons, Ordnance Div.; John W. Anderson, director of engineering, Inertial Guidance Center; George J. Schwartz, vice-president and general manager, Boston Div.; and M. B. Taft, general manager, Missile Equipment Div.

SECTIONS

Holloman Section: The Section held its monthly dinner meeting in August at the Officers' Open Mess of Holloman AFB. President Knox Millsaps opened the meeting by introducing Maj. Gen. and Mrs. Daniel E. Hooks, Dr. and Mrs. Albert H. Blatt, and Dr. and Mrs. Gerard H. de Vaucouleurs. Gen. Hooks is the AF Missile Development Center commander; Dr. Blatt is a distinguished organic chemist with Queens College; and **Dr. de Vaucouleurs,** the honored guest and featured speaker, is the noted astrophysicist now at Harvard Observatory.

Following the dinner, Dr. de Vaucouleurs discussed the latest information on the planet Venus, and explained the application of the latest techniques in optical and radio astronomy that have dispelled much of our ignorance of the nearest planet.

By careful observation and analysis, he said, the properties of the atmosphere of Venus have been reasonably well estimated. The conditions of Venus likely to be encountered by a space traveler are now fairly well known. The welcome by Venus for our intrepid astronauts will certainly be warm, but it will hardly be hospitable in any terrestrial sense of the term.

Man from the earth, concluded Dr. de Vaucouleurs, when he sets foot on Venus, will have to be very well insulated, and he will have to contend with the concentration of dust which seems to fill the lower Venusian atmosphere.

—Lt. Col. Harry L. Gephart, USAF

Houston: The theme of the September meeting of the Section was "Ultra-Sonic Inspection." Members learned about the use of sound inspection in the construction of rocket bodies and motors and similar constructions. Also, color films of some recent ICBM firings at Cape Canaveral were shown.

The new officers for this year are Lawrence Megow, president; Dennis Ashton, vice-president; C. B. Schreiber, treasurer; and J. B. Dancer, secretary.

—Ronald Pinkenburg

Sacramento: "A Tourist's Viewpoint of Russia" was presented by **Richard D. Geckler,** vice-president of Aerojet-General for its Solid Rocket Plant, at the July meeting of the Section. (The speaker was an invited guest at the 52nd General Conference of the Fédération Aeronautique Internationale held in Moscow; a prearranged tour of several cities in Russia followed the conference.) He commented on his experiences and presented numerous color slides of Russian people and scenes.

In Moscow, after some difficulties with Intourist, the Soviet Tourist Agency, he was allowed to visit a Russian bookstore with an interpreter. His experience, in his own words, is interesting.

"The interpreter rushed me so that I was only able to thumb the pages of a few books without much comprehension of them. Selecting what appeared to be a promising book on guided missiles, I paid for it and rushed off to a reception. Later that

On the calendar

1959	
Nov. 2–5	Combustion Institute Western States Section Fall Meeting on Chemical Equilibria and Performance of High Temperature Combustion Systems, IAS Building, Los Angeles.
Nov. 2–6	Annual Convention of Society for Nondestructive Testing, Hotel Hamilton, Chicago.
Nov. 5–6	8th Annual Instrumentation Conference sponsored by Louisiana Polytechnic Institute School of Engineering, Ruston, La.
Nov. 9–11	IRE Instrumentation Conference and Exhibit, Atlanta Biltmore Hotel, Atlanta, Ga.
Nov. 15–19	**ARS 14th Annual Meeting and Astronautical Exposition, Washington, D.C.**
Nov. 23–24	Symposium on Solid State Devices, sponsored by ISA, AIEE, IRE, Benjamin Franklin Hotel, Philadelphia.
1960	
Jan. 11–16	First International Space Science Symposium, and COSPAR Plenary Session, sponsored by COSPAR, Nice, France.
Jan. 14–20	6th Annual Meeting of American Astronautical Society, N.Y.C.
Jan. 28–29	**ARS Solid Propellants Conference, Princeton Univ., Princeton, N.J.**
Feb. 1–5	ISA Instrument-Automation Conference and Exhibit, Houston Coliseum, Houston, Tex.
Feb. 3–5	IRE Winter Convention on Military Electronics, Ambassador Hotel, Los Angeles.
Feb. 18–19	AIEE Symposium on Engineering Aspects of Magnetohydrodynamics, Univ. of Pennsylvania, Philadelphia.
April 6–8	National Meeting of the Institute of Environmental Sciences, Biltmore Hotel, Los Angeles.
May 3–5	IRE-AIEE Western Joint Computer Conference, San Francisco.
April 21–22	AIME Southwest Metals and Minerals Conference, Ambassador Hotel, Los Angeles, Calif.
Aug. 31–Sept. 7	10th International Congress of Applied Mechanics, Congress Bldg., Stresa, Italy.

Johns-Manville announces new **MIN-KLAD** Insulation!

This one new product answers 4 basic thermal and mechanical requirements
low conductivity
high heat capacity plus erosion resistance
high strength
Asbestos-reinforced plastic
Min-K insulation

New Min-Klad insulation is engineered and molded to your design requirements.

Combines the capabilities of asbestos-reinforced plastic with the dramatically low conductivity of MIN-K insulation!

New Min-Klad insulation may well be the most significant advance ever made in missile and rocket insulation.

Developed by Johns-Manville research scientists, Min-Klad is the only product of its kind, a permanent lamination of the missile industry's two most effective high-temperature materials: 1) reinforced plastic and 2) J-M's recently developed Min-K insulation.

Does more than plastic alone

Min-Klad gives the missile designer all the advantages of high-temperature plastic: Strength, toughness, rigidity! Erosion resistance! High heat capacity! Yet Min-Klad does more.

It also insulates . . . and with dramatic effectiveness! Its insulating element is J-M's Min-K, an insulation with thermal conductivity that is actually lower than the molecular conductivity of still air. And this conductivity (already less than half that of the best fibrous insulations) drops still further with altitude. At 10 miles, for example, it is decreased by as much as 40%, with further decreases at greater altitudes.

Wide range of applications

Min-Klad offers the missile and rocket designer a rich choice of heat-control possibilities. It may be used for a part that must insulate, yet have the structural advantages of plastic. Where requirements call for a scuff- and erosion-resistant insulating surface . . . or for a good adhesive bond between Min-K insulation and other surfaces. Or, it may be used to control high transient temperatures! For high heat capacity of asbestos-reinforced plastic combined with the low conductivity and heat capacity of Min-K result in a product that provides minimum heat transfer under transient conditions.

Min-Klad is now being tested for approximately two dozen missile and rocket designs. Why not investigate this new material for your present thermal requirements? Upon request, we'll be pleased to send you a sample of the material along with detailed technical information. Write Johns-Manville, Box 14, New York 16, New York. (Ask, too, for information on Min-K insulation and the new aviation insulation brochure IN-185A.) In Canada: Port Credit, Ontario.

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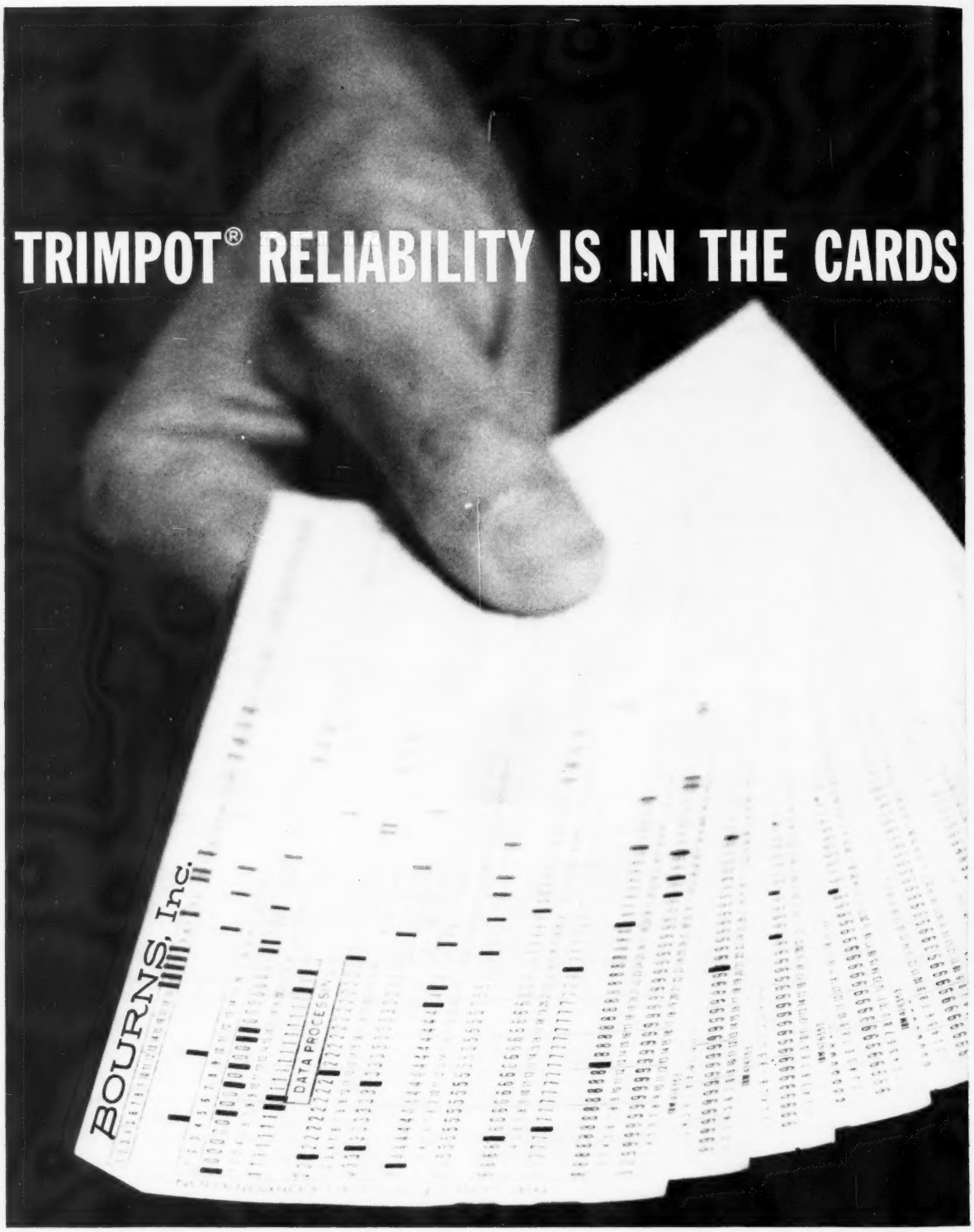

Test information punched in these cards can provide detailed performance reliability statistics on Trimpot production. The cards summarize extensive environmental tests which Bourns regularly conducts above and beyond regular quality control. In Bourns' own Reliability Assurance Laboratory, monthly samples are taken at random from factory stocks and completely tested for conformance to all environmental and electrical specifications on Trimpot catalog sheets. Results can then be fed into IBM computers which analyze performance data with corrective action taken immediately, if required!

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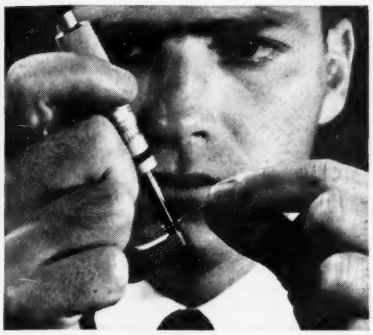


Trimpot reliability starts at the beginning. Here an incoming lot of potentiometer leadscrews undergoes a dimensional check.

From the time the element is wound until the lid of the potentiometer is installed, in-process inspection monitors quality.

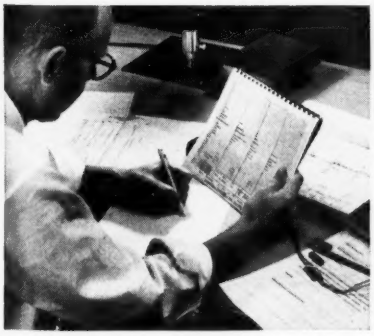
100% final inspection is made possible by this exclusive high-speed system developed by Bourns to test all major electrical characteristics. Critical dimensions of each unit are also checked.

And Reliability Assurance Tests Like These...

This vibrator for measuring conformance to Mil-Specs is an important part of the extensive equipment in Bourns Reliability Assurance Laboratory.

This chamber subjects potentiometers to standard military tests for humidity, provides important feedback on product performance.

1000-hour load life testing per Mil-R-19A takes place in ovens like this, which hold temperatures at desired levels at full rated power.



When tests are completed and the results tabulated, Bourns engineers plot frequency distribution curves from the steady flow of test results. Analysis of these curves and other data from testing provides a continuing check on all models to see that they meet the most exacting standards of performance. This analysis and the constant flow of information between the Testing and Production departments is your assurance that the Trimpot potentiometers you specify and purchase will meet specifications.

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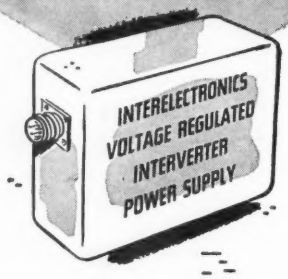

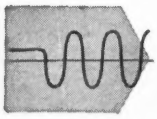

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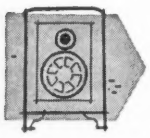

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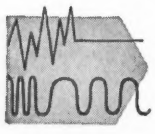
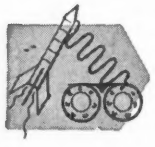


Now in use in major missiles, powering telemetering transmitters, radar beacons, electronic equipment. Single and polyphase AC output units now power airborne and marine missile gyros, synchros, servos, magnetic amplifiers.



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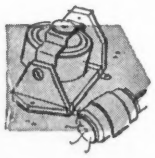

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night, on examining the book more carefully, I discovered I had a fine Russian translation of Grayson Merrill's 'Handbook on Guided Missiles,' first published in English.

"By contrast, if you are fortunate enough to have professional acquaintances in the Soviet Union before your trip, it is possible to see a great deal more of Russian life without the guiding hand of Intourist. On the train from Moscow to Leningrad, we met a professor from the Univ. of Chicago who was spending a few weeks discussing paleontology with his Russian colleagues in the Soviet Academy of Sciences. He had been shown the greatest hospitality both in the homes of the Russian scientists and in their laboratories, and apparently had complete access to their laboratories and even to their unpublished works.

"I was deeply disappointed, but not surprised, that I was not able to cultivate the acquaintance of any Soviet rocket scientist either at the conference itself or during our tour of six major Soviet cities. But then, rocketry, after all, is not paleontology."

—Ira Nagin

Southern California: At the August meeting of the Section, held at the Roger Young Auditorium in Los Angeles, **H. W. Merrill,** vice-president and general manager of Martin-Denver, discussed the Titan program. Titan's unprecedented success in flight-testing is the end result of a unique ground-test program (see August 1959 *Astronautics,* page 26). In size, thoroughness, variety, and scope, there has not been anything like its testing program. Going from blueprint to successful flight in 40 months, Titan has greatly advanced the state of the art of producing large missiles.

—Eric Burgess

CORPORATE MEMBERS

Aerojet-General announces merger of its Turbo-Machinery Div. with its Nucleonics subsidiary. . .At **AiResearch Mfg. Div.** of Garrett Corp., ground has been broken for the first increment of a projected 1 million-sq-ft manufacturing and research complex . . .**Aluminum Co. of America** is building a die casting plant at Edison Township, N.J., as replacement for the 37-year-old Garwood works. . . **Atlantic Research Corp.** recently acquired the research and engineering firm of Jansky & Bailey, Inc., as a wholly-owned subsidiary, and also a 16 per cent interest in General Communication Co., which owned J&B. . . **Bendix Aviation Corp.'s** semiconductor products expansion program is underway with the start of a 72,000-sq-ft facility in N. J. . . .**GE** has formed an Advanced Projects and Marketing Section within the Ordnance Dept. of the Defense Electronics Div. . . **Linde Co.** will build a liquid oxygen plant at Ft. Crowder Reservation, Neosho, Mo., to serve the Southwestern missile industry. The company played host to an international group of 150 cryogenic engineers and scientists during a tour of its Pittsburgh plant.

Marquardt Corp. has established a Nuclear System Div. in its Power Systems Group. Plans for a $1.25 million engineering and administration building for the Group have been approved by the board. . .**RCA** plans a 120,000-sq-ft plant in Mountaintop, Pa., to be devoted exclusively to products of its Semiconductor and Materials Div. . . . The new Navy flight-test facility at Hanscom AFB, Mass., to be operated by **Raytheon Co.** was recently dedicated. . .**Solar Aircraft** will build a new 62,000-sq-ft engineering and research building. . .**Sylvania Electric Products** has arranged to purchase 50 per cent of the capital stock of Fabbrica Italiana Valvole Radio Elettriche S. p. A. (Fivre), Italy's leading manufacturer of transmitting and receiving tubes. SEP has begun construction of a 6000-sq-ft facility for fabrication of refractory metals at Towanda, Pa., and a 32,000-sq-ft component manufacturing plant at Santa Cruz, Calif. . . .New manufacturing and testing facilities for medium and large rocket motors were recently unveiled at the Army's Longhorn Ordnance Works operated by **Thiokol Chemical.**

ASTRO Covers Available

In response to a number of requests, *Astronautics* is offering full-color reprints of its covers.

These reprints will be in the form of laminated plastic display plaques, with a metal D-ring on the back for easy mounting on a wall. The full-size cover, with a suitable mat, is mounted on $1/4$-in. rigid hardboard, with beveled edges, and over-laminated with transparent vinyl plastic. Size of the plaque is 11 by 12 in. Cost is $2.00, and only a ***limited supply*** of covers will be available each month.

The plaques may be obtained by writing to *Astronautics,* 500 Fifth Ave., New York 36, N.Y.

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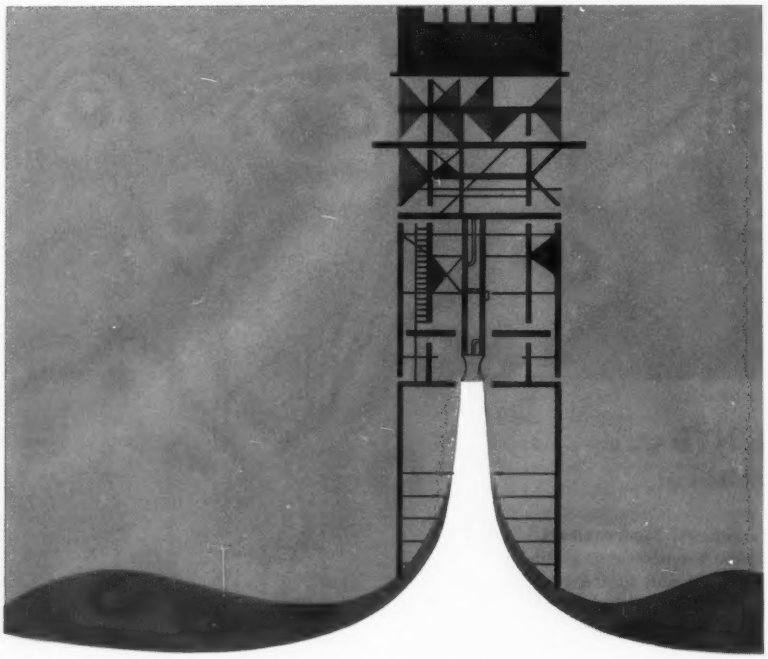

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Propellants

(CONTINUED FROM PAGE 45)

ARS Journal and the papers in the ARS Propellant Thermodynamics and Handling Conference, available this month (see Sept. 1959 *Astronautics*, page 48). In the latter were papers on the production, storage, transportation, and safety aspects of liquid hydrogen as well as experience in using it in engine testing. And, of course, the cryogenics conference in September at the Univ. of California had many interesting papers on this subject. Centaur, as an application of this growing technology, will be a pioneer in its field, and will be followed with great interest.

Fluorine as a high-energy oxidizer also received considerable attention during the past year. Allied Chemical Corp. opened a new plant late last year that can deliver tonnage quantities to rocket laboratories. The handling of fluorine, a crucial question in its application, was the subject of two sessions at the ARS Propellant Thermodynamics and Handling Conference. Problems of fluorine toxicity and handling of spillage and exhaust products were discussed, as well as production, transportation, and use in rocket systems. You can get a hot argument going among some rocket men over the relative merits of hydrogen-fluorine and hydrogen-oxygen systems.

Work continues on finding storable liquid propellants that have a high specific impulse. Some of this is in the realm of fluorine chemistry. (See, for example, John F. Gall's survey article in the February 1959 issue of the *ARS Journal*.) Others are directed at the light elements as fuels.

Solid propellants also had a busy year as more research was focused on control of propellant burning characteristics and on high-energy elements. Much of this is proprietary or classified information, or both. It can be told that aluminum is an important addition to solid propellants for its influence on combustion. Also, progress has been made in propellant formulations that make solids less sensitive to temperature and pressure.

The year saw many excellent contributions in combustion, as attested by the articles in our journals and in national and international meetings too numerous to mention. Progress is being made in understanding combustion oscillations, but there is still a long way to go. Oscillatory instabilities remain a big problem, and are usually avoided in particular development projects by expensive cut-and-try methods. ♦♦

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Performance data on DIMAZINE-powered rocket engines in military missiles and satellite launching vehicles shows DIMAZINE to be a highly reliable rocket fuel.

DIMAZINE provides fast, dependable hypergolic starts followed by smooth, stable combustion and easier shutdowns. Dependable instant readiness is assured for years by its outstanding stability during storage in missiles. It also has high performance, high thermal stability, low freezing point, low shock sensitivity, minimum susceptibility to contamination and high compatibility with almost all metals and appropriate sealing materials.

These manifold advantages combine to make DIMAZINE *the outstanding storable fuel*. We will be pleased to work with you in evaluating DIMAZINE and to supply detailed data on its properties and handling.

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ASTRONAUTICS Data Sheet — *Propellants*

Compiled by Stanley Sarner

Flight Propulsion Laboratory Dept., General Electric Co., Cincinnati 15, Ohio

UNSYMMETRICAL DIMETHYL HYDRAZINE (UDMH)—$(CH_3)_2NNH_2$

UDMH is a clear, colorless, hygroscopic liquid with a rather sharp ammoniacal or fishy odor generally characteristic of organic amines. It is one of the best rocket fuels available, having excellent physical properties and being capable of high-energy performance. UDMH may be used as a "ready" propellant; it is hypergolic with most high-energy oxidizers; and its properties indicate it should make an excellent coolant. The accompanying tables give some of the properties of this fuel.

Hazards

UDMH forms flammable or explosive mixtures with air from 3 to 45 per cent by volume. Its flash point is very low (34 F), but its autoignition temperature is extremely high (above 575 F).

UDMH is fairly toxic, a maximum allowable concentration of 0.5 ppm being recommended, but it is not corrosive. A respirator with an ammonia canister, splashproof goggles, and vinyl-coated gloves should be worn. If excessive splashing is expected, suitable splashproof garments should also be worn. Areas of the skin which contact UDMH should be thoroughly washed with water. Detection levels by odor are much lower than hazardous concentrations, giving automatic safe warning.

Materials

Processing, storage, and shipment equipment for UDMH is made of mild steel. No known limitation exists on the use of nickel, monel, or stainless steels 303, 304, 316, 321, or 347. Aluminum and its alloys and magnesium (Dowmetal 032) are good. Copper and high copper alloys should be tested under proposed use conditions since corrosion of copper by refluxing UDMH has been observed, although brass was essentially inert under these conditions. Easy Flow No. 145 silver solder appears satisfactory for use in brazing applications.

The best elastomers include Teflon, unplasticized Kel-F, polyethylene, Garlock gasket 900, Hydrapol rubber, and graphite. Kel-F, certain butyl rubbers, and Hydrapol rubber would be serviceable for O-rings. Garlock 900, polyethylene, and Teflon have all given excellent service in gaskets. Hose materials include flexible stainless steel, polyethylene, Teflon, and Kel-F. Conventional centrifugal pumps with graphite impregnated asbestos or braided Teflon packing have been used. In addition, seal-less centrifugal pumps can also be used. Xpando and Q-seal are satisfactory pipe dopes. Lubricants are more difficult to find because of the solvent properties of UDMH, but a mixture of graphite and Apiezon L is currently recommended.

Care should be taken to avoid the introduction of mercury into UDMH, since azide-type products may result.

Cost and Availability

Tank car quantities are available. Prices on UDMH vary from $8 for one pound and $3.50/lb for 50-lb quantities down to $2.40/lb in 335-lb drums and $1.90/lb for 15 drums or $1.75/lb for tank-car quantities. A price drop to about $0.50/lb at a production rate of 25 to 50 million pounds per year is estimated.

Table 1 Physical Properties of UDMH

Freezing Point	−57.2 C	−71.0 F
Boiling Point	63.1 C	146 F
Critical Temperature	250 C	482 F
Critical Pressure	53.5 atm	786 psia
Vapor Pressure at 25 C (77 F)	0.206 atm	3.03 psia
Density at 25 C (77 F)	0.783 g/cm^3	48.9 lb/ft^3
Viscosity at 25 C (77 F)	0.51 cps	...
Flash Point (Tag closed cup)	1 C	34 F
Molecular Weight	60.102	...
Thermal Conductivity at 25 C	...	0.12 Btu/hr ft F

Table 2 Chemical Properties of UDMH

Heat of Formation (liquid) at 25 C	+12.7 kcal/mole
Heat of Vaporization at 25 C	8.37 kcal/mole
Heat of Fusion at Freezing Point	2.41 kcal/mole
Heat of Capacity at 25 C	39.2 cal/mole C
Maximum Allowable Concentration in Air	0.5 ppm

Table 3 Theoretical Performance of UDMH*

Oxidizer	Specific Impulse (sec)		Chamber Temperature**
	Frozen Flow	Equilibrium Flow	(Deg K)
O_2	295	310	3594
95% H_2O_2	272	278	2922
N_2O_4	274	285	3413
ClO_3F	275	290	3693
ClF_3	269	280	3772
RFNA	267	276	3222

* P_c = 1000 psia; P_e = 14.7 psia; optimum O/F ratio.

** Corresponds to equilibrium flow impulse.

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Amcel Propulsion, Inc., is an affiliate of Celanese Corporation of America. It is established to coordinate the manufacturing, research, and production of Celanese in a comprehensive missiles program.

The Amcel plant at Asheville, North Carolina, includes a 1300 acre tract with test range, manufacturing facilities, equipment, laboratories, etc. This plant is fully equipped for research, development, engineering, and prototype production of propellants, propulsion systems, and assembly facilities for rockets, missiles, gas generators, auxiliary power units, and related items.

PROPELLANTS

As a major producer of organic chemicals with a 35 year background of research in polymer chemistry, Celanese is uniquely qualified to make significant contributions to the science and technology of high energy fuels. Many Celanese chemicals, as well as its high alpha cellulose, offer important potentialities in this field. Years of experience in nitration techniques, and in plastics and fibers production, provide a solid basis for the development of more powerful and efficient fuels and improved thrust chamber architecture.

RESEARCH

Celanese research laboratories at Clarkwood, Texas and Summit, New Jersey, will be coordinated with the program at the Amcel plant. This integrated program is designed to provide a more complete exploration of all phases of the problems of thrust and thrust design. Emphasis will be on solid fuels and fuel components, as well as the potentialities of original chamber design and construction, propulsion unit design and manufacture, and related propellant and explosives fields. Amcel Propulsion Inc., 180 Madison Ave., New York 16, N. Y.

The originality of many aspects of the Amcel program, and the potentials they suggest, should be of considerable interest to scientists who are or intend to be specializing in this field. If your activities are in this area, you are invited to get in touch with us. Address E. O. Whitman, Personnel Director, Amcel Propulsion Inc., 180 Madison Ave., New York 16, N. Y.

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(CONTINUED FROM PAGE 35)

take the occurrence of dissociation and recombination of air molecules into account.[5-9]

Consideration of the effects of finite rates of dissociation and recombination upon hypersonic flow fields fixes attention on the requirement for fundamental reaction-rate data for dissociation and recombination rates of the components of air, particularly oxygen and nitrogen. Despite the lack of a universally accepted reaction rate theory, some experimental data have been taken. Recent among these experiments are those reported by Camac, et al.,[10] and Matthews[11] wherein the recombination rate for oxygen, for example, is shown to be of the order of 10^{15} to 10^{16} cm^6 per $mole^2 sec$ at temperatures of concern in hypersonic gas dynamics. Also, equilibrium composition and thermodynamic properties of hot air continue to be published in convenient form.[12]

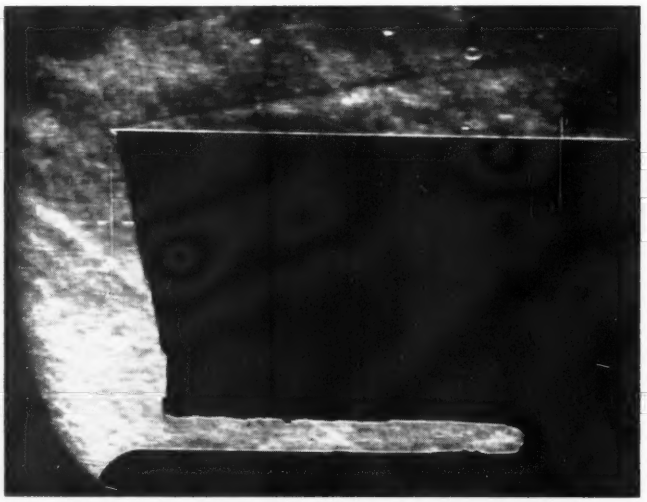
To this point, we have discussed inviscid flow fields exclusively. Fay and Riddell recently published an analysis of the hypersonic laminar boundary layer at the stagnation point of a blunt body for both equilibrium and nonequilibrium flow.[13] Kemp, et al., extended this treatment to regions away from the stagnation point of a blunt body and reported experimental verification of the theory.[14] The graph on page 35, shows the theory and experiment. Agreement between the two for this body is quite acceptable.

Chief among the results shown by these theories is an indication that the concept of local similarity is a valid and useful one in analyzing the hypersonic laminar boundary layer away from the stagnation point and that the use of a noncatalytic surface could reduce the rate of heat transfer to the surface. Goulard studied the quantitative effect of various surface recombination rates on the rate of heat transfer to the surface.[15]

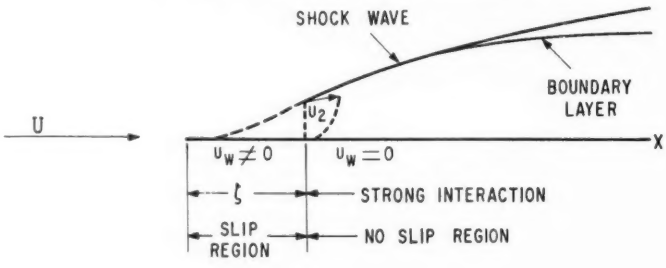
Considerable progress on the effects of burning and other chemical reactions resulting from mass addition to the hypersonic boundary layer was made during the subject period. Lees reported in detail the effects of reactions occurring in the laminar and turbulent boundary layer involving sublimating or vaporizing surface material.[16] He shows that, in the laminar hypersonic boundary layer, combustion of the surface material can be advantageous if the heat of sublimation of the surface material is comparable with the gaseous heat of reaction. Cohen, et al., treat a similar problem and particularize on a carbon-(graphite)-oxygen exothermic reaction.[17]

Attention has begun to be devoted to the hypersonic turbulent boundary layer. The case for a hypersonic turbulent boundary layer over a very cool surface has been studied and reported by Rose, Probstein, and Adams.[18] It appears that the classical turbulent boundary-layer equations can be adapted to this problem once proper terms accounting for dissociation, recombination, and diffusion of atoms and molecules are incorporated into the equations.

None of the above boundary-layer theories would be complete without knowledge of the transport properties of high-temperature dissociated air. During the period, such transport properties were published by Hansen[19] and Scala and Baulknight.[20]



Mach 19.6 flow over a flat plate, showing evidence of slip flow near leading edge, which can be interpreted with aid of graph below. Reynolds Number per inch equals 15,670 and Knudsen Number equals 1.85 based on leading-edge thickness and local-stream mean free path. After Nagamatsu and Sheer (see Reference 48).



Raises Some Questions

It is becoming increasingly apparent that a desirable lightweight heat-protection system for short-time exposure at hypersonic flight conditions makes use of a melting, vaporizing, or ablating surface material. The use of such a material, in turn, raises questions about the interaction of the material leaving the surface with the boundary layer, and its effect upon the heat transfer to the surface.

Sutton was among the earliest to report a study of this problem, treating the case of a melted glassy material flowing contiguously with an external hypersonic laminar boundary layer and finding the melting rate to be linearly dependent upon the heat-transfer rate.[21] More recently, a similar problem was treated and reported by Bethe and Adams.[22] This latter study included the effects of vaporization and glassy liquids of differing viscosities. The viscosity directly affects the amount of material vaporized.

With the successful orbiting of satellite vehicles has come a reawakened interest in hypersonic, low-density, gas dynamics. It should be immediately apparent that the survival time of any satellite is dependent upon its low-density drag. When designers turned

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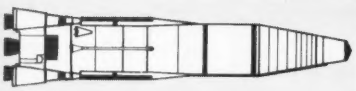
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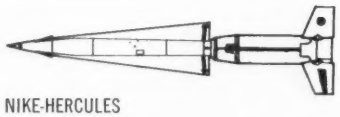
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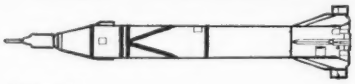
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to the methods available for estimating low-density aerodynamic drag, it became apparent that this time-honored field was far from a closed subject from the researcher's point of view.[23-27]

Along with the awareness that a hypersonic boundary layer contained particles came the suggestion that the paths of these particles could be influenced by impressed electromagnetic and electrostatic fields. Hypersonic body drag and heat transfer might be thus controlled, for example.

A host of papers in this field appeared during 1958 and 1959. Neuringer and McIlroy,[28] Rossow,[29] Kemp,[30] Meyer,[31,34] and Bush[33] concerned themselves with reducing the heat transfer from a laminar boundary layer flowing around a hypersonic blunt body to the body surface. It was found that magnetic field strengths of the order of 100 to 1000 gauss are required to reduce heat-transfer rates appreciably for naturally ionized boundary layers. Bleviss[32] treated the case of hypersonic Couette flow interacting with a uniform magnetic field normal to the walls. A study of this simple geometry helps illustrate in a fairly straightforward manner the possible effects of a magnetic field on a partially ionized laminar boundary layer.

Problem Studied Early

Most hypersonic bodies, be they wings or fuselages, have blunted tips or leading edges to reduce heat-transfer rate and/or increase the thermal capacity per unit surface area. Because of this, the aerodynamics of the inviscid flow field between strong leading-edge shockwaves and the body surface came to early attention of aerodynamicists, and considerable progress was made prior to 1958.

Nevertheless, Garabedian and Lieberstein published a fresh approach to this problem in 1958.[35] In this approach, they start out with the shape of the shockwave specified and proceed to calculate the body that goes with it through a stable scheme of computation by finite differences. A distinguishing feature of this approach is its proper handling of the subsonic flow regime, which has always remained the most difficult portion of the blunt-body flow-field problem. Their reported calculations are in excellent agreement with experiment.

Van Dyke reviewed all previous solutions to the hypersonic blunt-body flow-field problem and proposed a numerical method simpler than previous ones.[36] The agreement of his method with that of Garabedian and Lieberstein is excellent where the two methods have been compared.

The analogous blunt-leading-edge problem for wings has tended to be overshadowed by the blunt-body problem in recent years. However, Hammitt recently published an experimental and theoretical study of the interaction of the blunted-flat-plate-leading-edge bow shockwave with the laminar boundary layer over the plate.[37] It was found that plate surface pressures and skin friction were increased over that expected for a sharp-leading-edge plate and that theory and experiment were in satisfactory agreement.

Aeroelastic Studies

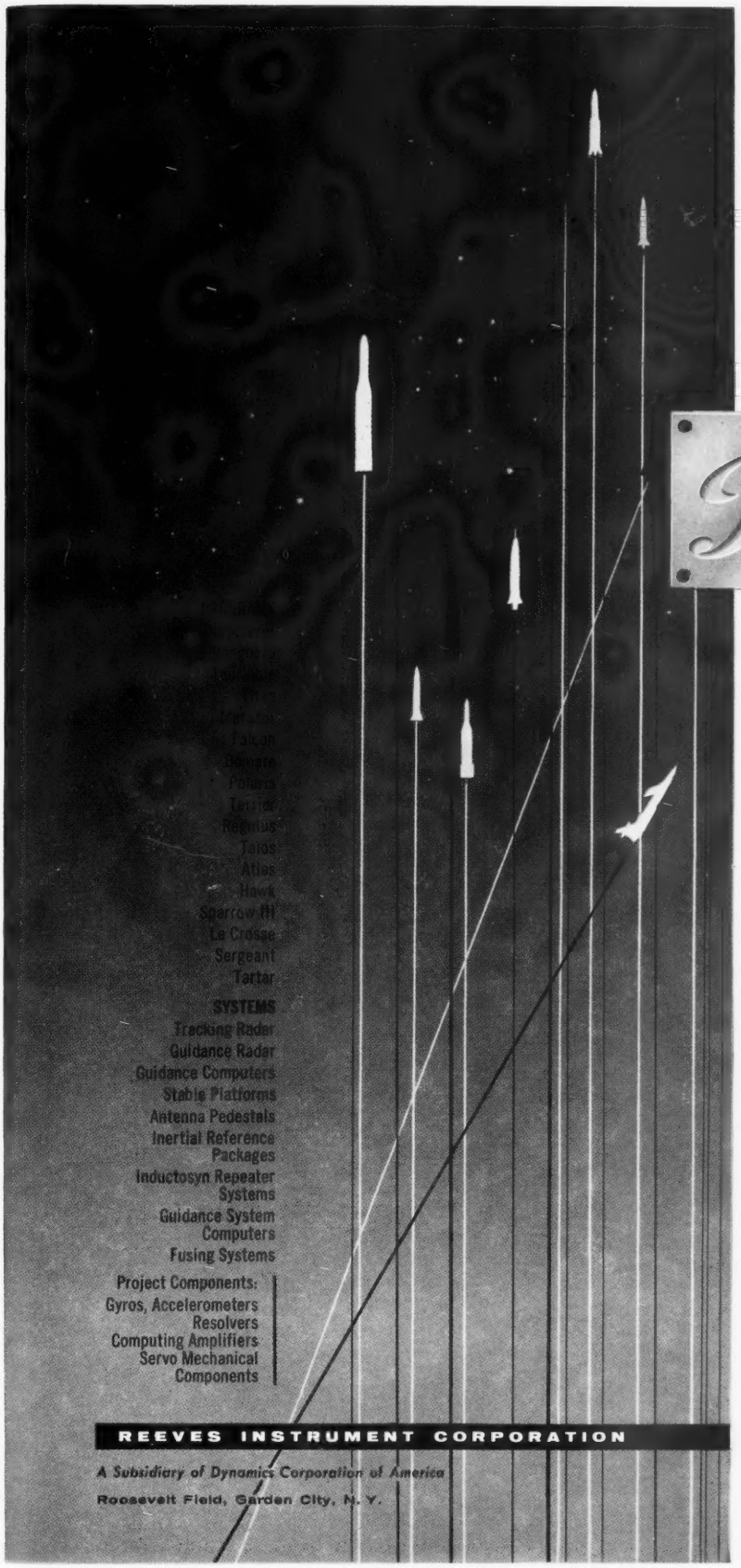
Hypersonics has progressed to the point where aeroelastic studies for hypersonic wings are being made. One of the useful and conceptually simple and accurate theories for such analyses is the "piston theory" first used by Dorrance[38] and Lighthill.[39] The foundations of this theory were recently elaborated upon by Bird.[40] The theory appears to be quite useful for thin wings over a wide range of hypersonic Mach numbers. Recent numerical aeroelastic studies for hypersonic wings were reported by Chawla[41] and Morgan, et al.[42] The latter paper compares the results of piston theory with other theories available.

The years 1958 and 1959 were notable for the progress made in developing and perfecting hypersonic-gas-flow test facilities. Previous years had seen the development of shock tube and conventional wind-tunnel techniques to a high degree of perfection.

Bloxsom reported the development of a technique of heating a reservoir of air to high temperature by condenser discharge.[43] This approach led to the so-called "hotshot" wind tunnel. The hypersonic shock tunnel—the marriage between the shock tube and wind tunnel—was reported in detail by Nagamatsu, et al.[44]

Eckert reported a novel device for studying partially ionized gas flows.[45] Eckert's objective was to develop a plasma flow device at temperatures not precluding continuous operation. The cool mercury plasma tunnel resulting from this research is shown in operation on page 35. The luminosity exhibited attests to the partial ionization of mercury vapor by an atom-ion collision process controlled by a superimposed radio-frequency discharge.

Considerable progress was reported in 1958 and 1959 toward verifying various hypersonics theories with experiment. Early in 1958 Rose and Stark[46] reported agreement between shock-tube measurements of stagnation-transfer rates with the laminar-boundary-layer stagnation point theory of Fay and Riddell.[13] Kubota,[47] using



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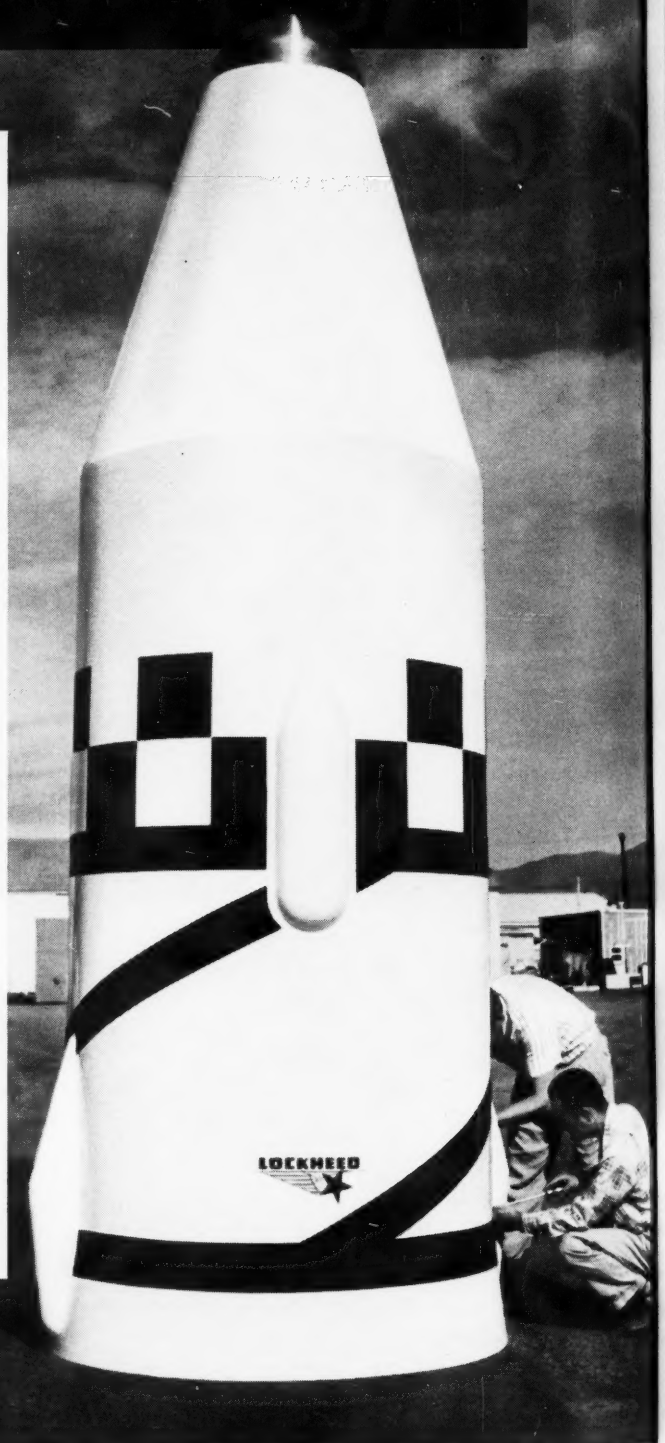

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a clever technique employing ice models in a conventional hypersonic tunnel, reported ablation rates in agreement with the theory of Lees.[16]

Nagamatsu and Sheer were able to create very high Mach number flows using their shock tunnel.[48] Surface-pressure measurements were made on a series of sharp-leading-edge flat plates at Mach numbers from 7.80 to 19.6. Among their findings were agreement with previously proposed shockwave–boundary layer, strong-interaction theory. Perhaps more significant was photographic evidence of the occurrence of slipflow near the sharp leading edge. The picture on page 78 is a Schlieren photograph taken at Mach 19.6. The curvature in the shockwave near the leading edge can be interpreted as evidence of slipflow with the aid of the graph associated with the photo.

Not all studies of dissociation in a gas stream need be concerned with high-temperature gas flows. Wegener, et al.,[49] reported a study of the effect of recombination of dissociated N_2O_4 on the flow field as it flows from a heated reservoir through an expanding nozzle to a Mach number of 1.9. Since N_2O_4 dissociates at a fairly low temperature (the supply temperature in these experiments was about 360 F), conventional wind-tunnel techniques can be used with their concurrent large test sections and long running times. This technique opens a new experimental approach to studying chemical reactions in a gas stream.

Demetriades was able to find the existence of damped and undamped oscillations within a laminar boundary layer over a flat plate in a Mach-5.8 wind tunnel.[50] These measurements appear to lend support to boundary layer stability theory at a much higher Mach number than heretofore investigated.

Talbot, et al,[51] reported the measurement of pressure distributions over blunted cones at low Reynolds numbers and Mach numbers from 3.6 to 5.8. In general, these results appear to agree with measurements taken at the same Mach numbers at much higher densities. Satisfactory agreement with appropriate theory was shown.

Experiments in magnetohydrodynamics reported included those of Patrick and Brogan[52] who reported the results of a theoretical and experimental investigation of the interaction of a steady magnetic field on a one-dimensional inviscid, compressible flow. Satisfactory agreement between theory and experiment was found in this pioneering effort to obtain experimental verification of the multicomponent magnetogasdynamic theory.

No report on progress in hypersonics would be complete without referring to progress in end products, including, for example, re-entry nose cones. The ever-increasing occurrence of the announcement that a successful long-range flight of an ICBM nose cone has taken place is taken as evidence that design practices based upon hypersonic theory are sound and that laboratory success is duplicated in full-scale free-flight tests.

The appearance of a text in hypersonics helps signal the maturity of this new branch of the sciences. Hayes and Probstein's book serves as an excellent testimonial to the progress made to date in this rapidly advancing field.[53]

Acknowledgment

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Design

(CONTINUED FROM PAGE 41)

(and aircraft) projects, there have been a number of unsuccessful shots in the various programs involving these missiles. One of the disadvantages of the great public interest in spaceflight is undue concern over each failure. More important in the long run is the variety of successful shots which involved several different missiles and many different contractors and agencies. The chief conclusion to be drawn from these successful shots is that a great capability for space-vehicle design, construction, and operation is growing steadily among many different organizations in this country.

Plans for the future have now been formulated which would have been ridiculed only two years ago. The Saturn booster, a device which at $1^1/_2$ million lb of thrust is about four times as powerful as either the Atlas or the Titan, is under construction. Additional high-performance stages (Vega and Centaur) are planned for the Atlas which will give substantially higher probe capability than any to date. A $1^1/_2$ million-lb-thrust single-chamber booster engine is under development, and plans are underway for utilization of clusters of these engines in NASA's Nova vehicle. This is the largest rocket vehicle programed to date, and is adequate for placing Man on the moon and returning him to earth.

Returning from Space

The problems of returning from space are being tackled vigorously in the NASA Mercury project. Successful nose cone re-entry experiments of the last year indicate a solution to a problem once thought to be almost insoluble, and generate confidence that return from space can be successful.

Moreover, the next generation of space propulsion systems may have been instigated with the successful firing of the first nuclear-rocket motor, Kiwi-A. It is too early yet to ascertain the actual impact of nuclear rockets upon spaceflight, just as it was too early to see completely the effects of the jet engine on aircraft development in 1945.

Further refinement of missile systems as the most effective weapons of the future seems inevitable. The array of space vehicles under development represents a substantial space capability up to and including placing several men on the moon and returning them safely. Furthermore, it is not envisioned that large technological breakthroughs will be required to implement these vehicles, although high-level engineering efforts will be required.

Hence, the state of the art in space-vehicle design clearly seems ready for large expansion into major space operations. ◆◆

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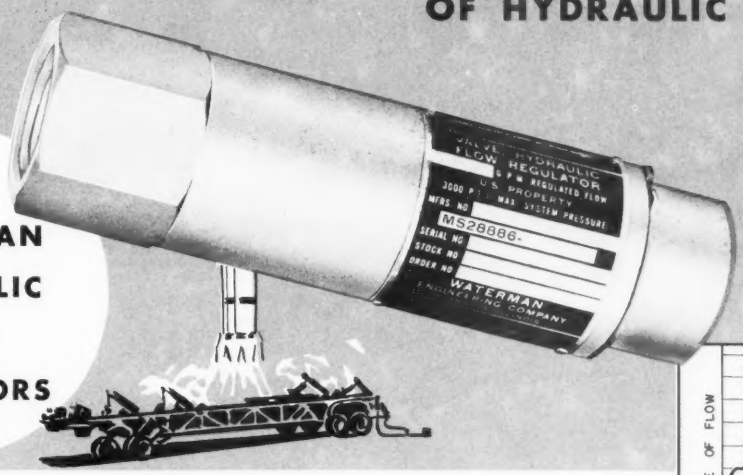

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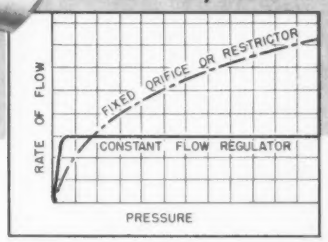

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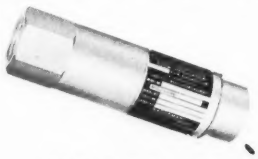

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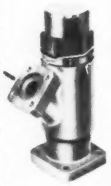

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Power Systems

(CONTINUED FROM PAGE 44)

with storage of gaseous hydrogen and liquid oxygen. Depending upon mission duration, less than 1.21 lb/kwh appears possible if methods of liquid-hydrogen storage can be developed.

Regenerative fuel cell systems may employ nuclear or solar energy to dissociate compounds which can then recombine in a fuel cell. Closed-cycle fuel cell systems which appear promising include the hydrox cell (H_2O), NOCL, and lithium hydride types. Severe developmental problems include efficient photochemical or high-temperature thermal regeneration of fuel and product separation in a zero-g environment. It appears that closed-cycle fuel cells may become competitive in medium-powered (<10 kw) applications, offering within the next few years specific weights of 100–50 lb/kw and over-all conversion efficiencies on the order of 10 to 20 per cent.

Solar Cell. The solar cell is a photovoltaic cell which directly converts the energy of incident solar photons to electric current. Present cells made of doped crystalline silicon have achieved solar-radiation conversion efficiencies of 15 per cent in laboratory specimens. Cells can be obtained commercially with guaranteed efficiencies of 9 per cent at room temperature. The output voltage of a single cell is approximately 0.4 volt in use; series circuits are required for high-voltage outputs. Solar-cell arrays with weight on the order of 0.5 lb/sq ft are currently practical. With the supporting framework and other auxiliary equipment included, a solar-cell power system could provide on the order of 150–100 lb/kw with present techniques.

May Become Workhorse

For the immediate future, solar cells may become the workhorse power system for space until more advanced solar or nuclear systems are developed. Improvements may include lighter supporting structures, new materials with higher conversion efficiency, and the use of spectrally selective filters for control of low-temperature emissivity. These improvements should lead to specific weights on the order of 50 lb/kw within the next few years.

The present cost of solar cells is high—on the order of $3/cm^2$, or equivalently about $300/watt. Improved manufacturing techniques may halve this cost in the near future. A system using solar cells encounters two problems common to all systems using solar energy: The need for orientation and a lightweight, efficient storage device for use in a satellite orbit. The solar cell accepts radiation throughout a 180-deg field angle, making unoriented or semioriented systems possible at the cost of using more cells.

Solar-Thermal. Solar-thermal systems for space will use concentrated solar energy for heating a material which transfers solar energy to thermionic emitters, thermocouples, dynamic heat engines (e.g., turboalternators and reciprocating engines), and possibly other energy converters. Analysis shows that the weight of the concentrator will dominate system weight. A parabolic mirror is necessary to achieve the high temperatures necessary for thermionic emitter or efficient turbine operation.

Heavy Structures Used

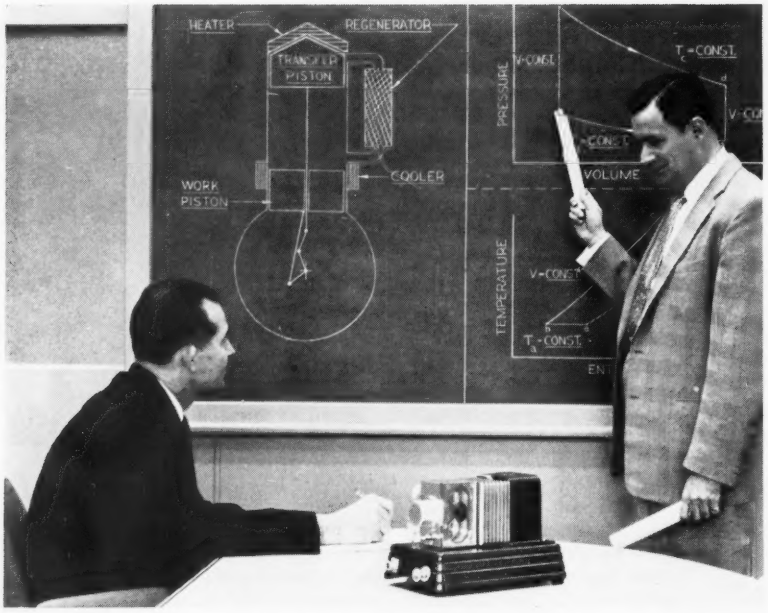
The geometrical tolerance on the mirror surface should be less than $\pm 1/4$ deg. At present, the only method of making large-scale solar concentrators with sufficient accuracy is by using rigid, heavy structures which weigh on the order of 1 to 2 lb/sq ft. Experiments with lightweight structures, such as balloons filled with polyurethane foam or umbrella-like ribbed structures with thin aluminized Mylar stretched over them, have not produced sufficient accuracy. Construction of an adequate concentrator represents perhaps the major

Sighting on Solar Power

Niles Schuh (left) and Ralph Tallent, research engineers with Westinghouse and Boeing, respectively, put a bench model of their solar-powered thermoelectric generator for space vehicles through a run. The generator without the aluminum mirror and frame weighs 3 lb and is designed to deliver 2.5 watts.

Nuclear Turbogenerator for Space Vehicles

The model shows GE proposal for nuclear turbogenerator, within the reach of near-future technology, for supplying power to space vehicles with electrical propulsion systems. This system—envisaged as about 70 ft long, 12 ft in diam, and 13,000 lb in weight—would use a liquefied metal such as potassium as a working fluid.



Sterling-Cycle Engine for Space Power

GM Allison Div.'s Tibor F. Nagey and Herbert L. Karsch talk over 1-cu-in. displacement Sterling-cycle generator (on table) which can produce 1.5 hp. Proposed by Allison for space vehicles, the high-efficiency engine runs off a variety of heat sources—solar, chemical, etc.

problem in developing a solar-thermal type of system.

The thermal-energy converter which produces the lightest over-all system weight at present is the Rankine-cycle turbine using mercury as a working fluid. The principal advantage of a turbine over a thermoelectric device is the high efficiency attainable (on the order of 30 to 35 per cent). A Rankine cycle using a condensing vapor is preferable to a gas cycle (e.g., the Brayton cycle) because of the more efficient transfer of waste heat to the radiating surface for rejection into space and consequent reduction of radiator weight. High-temperature operation is desirable to reduce radiator weight, and the development of turbines using sodium, rubidium, or other "exotic" working fluids will produce lighter systems. Recent developments with the Philips engine (Sterling cycle) have resulted in devices 30 to 35 per cent efficient, placing this engine in strong competition with Rankine turbines if reliability can be proved.

Rapid advancements are taking place in developing the solid-state thermocouple and the thermionic emitter. Thermocouple efficiency of 14 per cent has been achieved in the laboratory, and thermocouples of 6 to 8 per cent efficiency are commonly used in such units as the Snap III nuclear power supply. It is anticipated that thermocouple efficiency will rise to 20 to 25 per cent within 5 years.

Efficiency Improving

Thermionic-emitter efficiency of 20 per cent has been achieved with the cesium-vapor diode and 13.5 per cent with the vacuum diode. The cesium diode is still in the experimental stage; but a vacuum type capable of 4 to 5 per cent efficiency will soon be commercially available. Attainable efficiencies within the next few years should rise to the neighborhood of 40 per cent using vapor and 20 per cent using close-spaced vacuum diodes. A solar thermionic emitter system could be extremely lightweight because of its high operating temperature and high efficiency, which reduce both mirror and radiator weight. The emitter cathode, however, requires high-temperature heat sources (1500 to 3000 K), which are beyond the capabilities of nuclear reactors at present and in the near future, and can only be attained by highly accurate solar concentrators.

Primary because of low efficiencies, systems using available thermoelectric devices would be heavier than turbine systems because of the increased mirror, radiator, and other component weight. On the other hand, static heat engines have the advantage of fewer moving parts or fluids in the over-all system, and therefore more inherent reliability. Thermoelectric systems also show advantages at lower power ranges (less than 1 kw) where dynamic heat-engine efficiency decreases. Specific weights of 75 to 100 lb/kw appear possible in the near future in the 1 to 10 kw range. Solar cells appear to offer lightest weight at the lower power levels (<1 kw).

Will Become Competitive

Developments in thermoelectric devices in the near future will make them strongly competitive with dynamic-heat-engine systems. The possibility exists of placing in series the thermionic emitter (which uses a very high temperature heat source) and thermocouple heat (which uses the rejected emitter).

Nuclear energy sources are logically divided into two types, those based on nuclear reactors and those based on radioisotopes. Nuclear-reactor power output is relatively constant for long-mission durations, compared to radioisotope sources, which have an exponentially decreasing power output with time. This time decay, coupled with the large amounts of power per unit mass obtainable with shortlived isotopes, bring about weight advantages in the 10 to 200 day range.

Major programs are presently analyzing and designing systems wherein a nuclear heat source provides energy to static and/or dynamic heat engines. Notable among these programs are the Snap developments. The most advanced systems experimentally are those which utilize Rankine mercury turbines in conjunction with radioisotope and reactor sources at power levels less than 10 kw.

The complex considerations in selecting a radioisotope include availability, cost, half-life, type of decay particle, and radiation hazards. It appears at present that radioisotope systems, because of the previous considerations, will offer weight advantages at power levels of a few kilowatts or less.

For power levels above the range of 10 to 20 kw and for durations of greater than a few days, it appears that nuclear reactor-turboelectric systems offer the lightest systems for the near future. Further development of thermoelectric devices will offer strong competition to rotating machinery.

At high power levels (greater than

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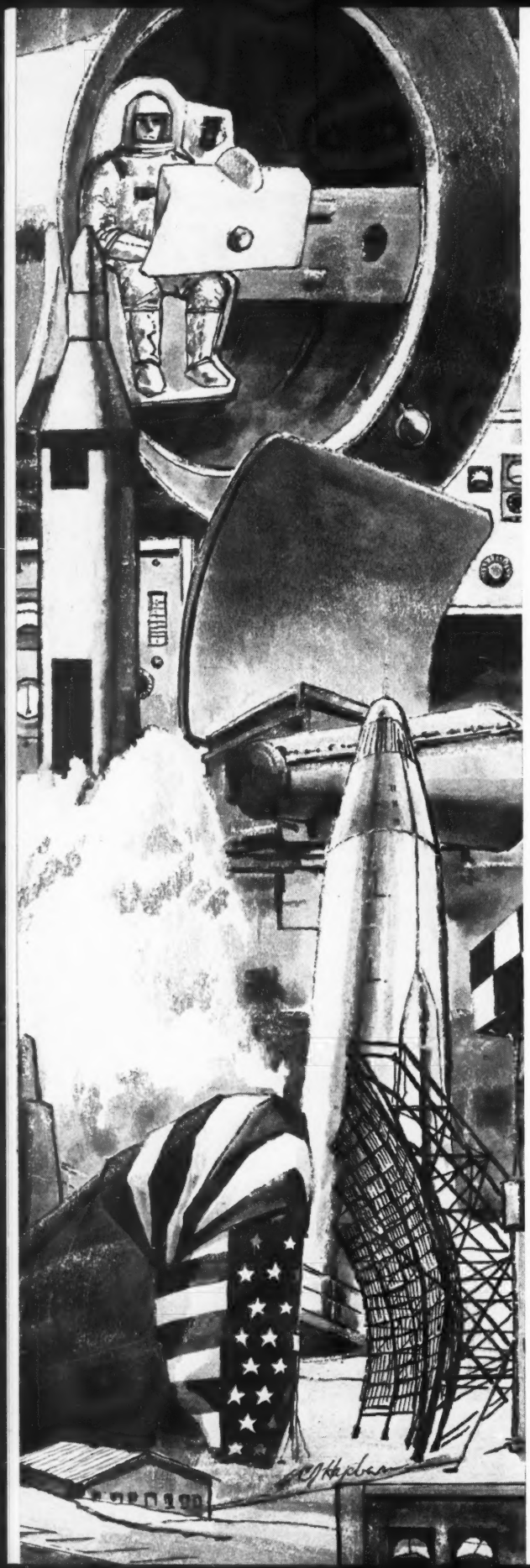

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100 kw) the radiator dominates nuclear system weight, and operating conditions should in general be selected to reduce radiator weight. Minimum radiator area occurs at a relatively fixed value of the ratio (approximately 0.75) of turbine outlet to inlet temperature. The heat-source temperature should therefore be as high as possible to maximize radiator temperature and minimize radiator area. The radiator must be designed with either excess capacity, protective devices, or self-sealing mechanisms to compensate for destructive effects of meteoroids.

Reactor weight is a comparatively small part of the total powerplant weight at high power levels, but becomes an appreciable percentage at power levels below 100 kw. Shield weight is roughly half system weight at lower power levels, but becomes approximately 20 per cent at high power levels.

In conclusion, the three main types of energy systems offer the following characteristics:

Chemical Energy Systems: These systems are lightest for short duration and/or low power level applications where low amounts of energy are consumed. They will continue to be used for some time because of their availability, low cost, and reliability of operation.

Solar Energy Systems: These systems will offer the lightest weight for power levels below 10 to 20 kw for durations in excess of 100 to 200 days. Solar systems face the problem of suitable energy storage and continuous orientation.

Nuclear Energy Systems: Nuclear reactor-thermal systems will definitely be preferred for high-power levels ($\gtrsim$ 10 kw) within the next few years. Static heat engines will offer strong competition to turbines when practical operating devices reach efficiencies on the order of 25 per cent. Major problem areas still exist in the area of lightweight radiators and shields.

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Ion Propulsion

(CONTINUED FROM PAGE 37)

rate may be increased by increasing the catalyst temperature, an increase in the tungsten temperature permits operation at higher flow rates and current density levels. However, in the temperature and flow-rate ranges of interest, thermal radiation losses from the hot tungsten can be significant. Consequently, it is desirable to operate the source at as low a temperature as possible, consistent with the requirement that the temperature be above the critical temperature for the flow rate desired.

The table on page 96 shows how these quantities vary. It should be observed that, with cesium ions, a specific impulse of 5000 sec corresponds to an acceleration voltage of about 1600 volts and a beam power of 1.6 watts/ma. It is easily seen that a high ion current density, with the associated high source temperature, is a prerequisite to good power efficiency.

Among the possible directions of ion source research in the near future are the following:

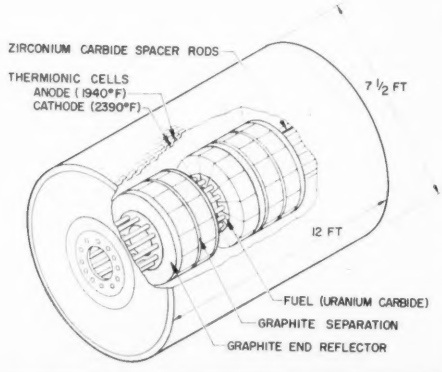
1. Measurement of the ion/atom ratio in high-current-density sources.

2. The development of a catalyst which will perform as well as tungsten at lower current densities and operating temperatures. This is especially important for low-I_{sp} accelerators for which a low power-loss-per-ma is necessary, and for which high current densities are difficult to obtain, because of space-charge saturation limitations.

3. The development of a high-temperature catalyst with a slightly higher work function than tungsten. Catalyst evaporation rates must also be considered in comparing these catalysts. One possibility might be rhenium, which has a work function of 5.1 electron volts (polycrystalline form) and a high melting point. The table on page 96 lists work functions and melting points of some metals.[2]

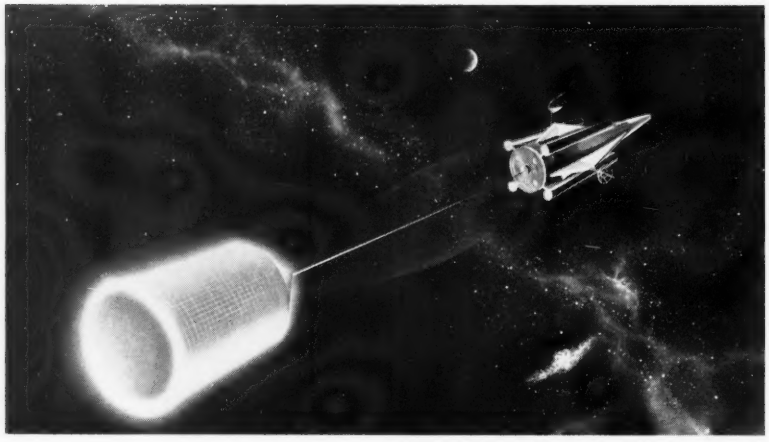
4. The investigation of different types of source configurations—porous plugs, woven grids, louvered structures, and others.

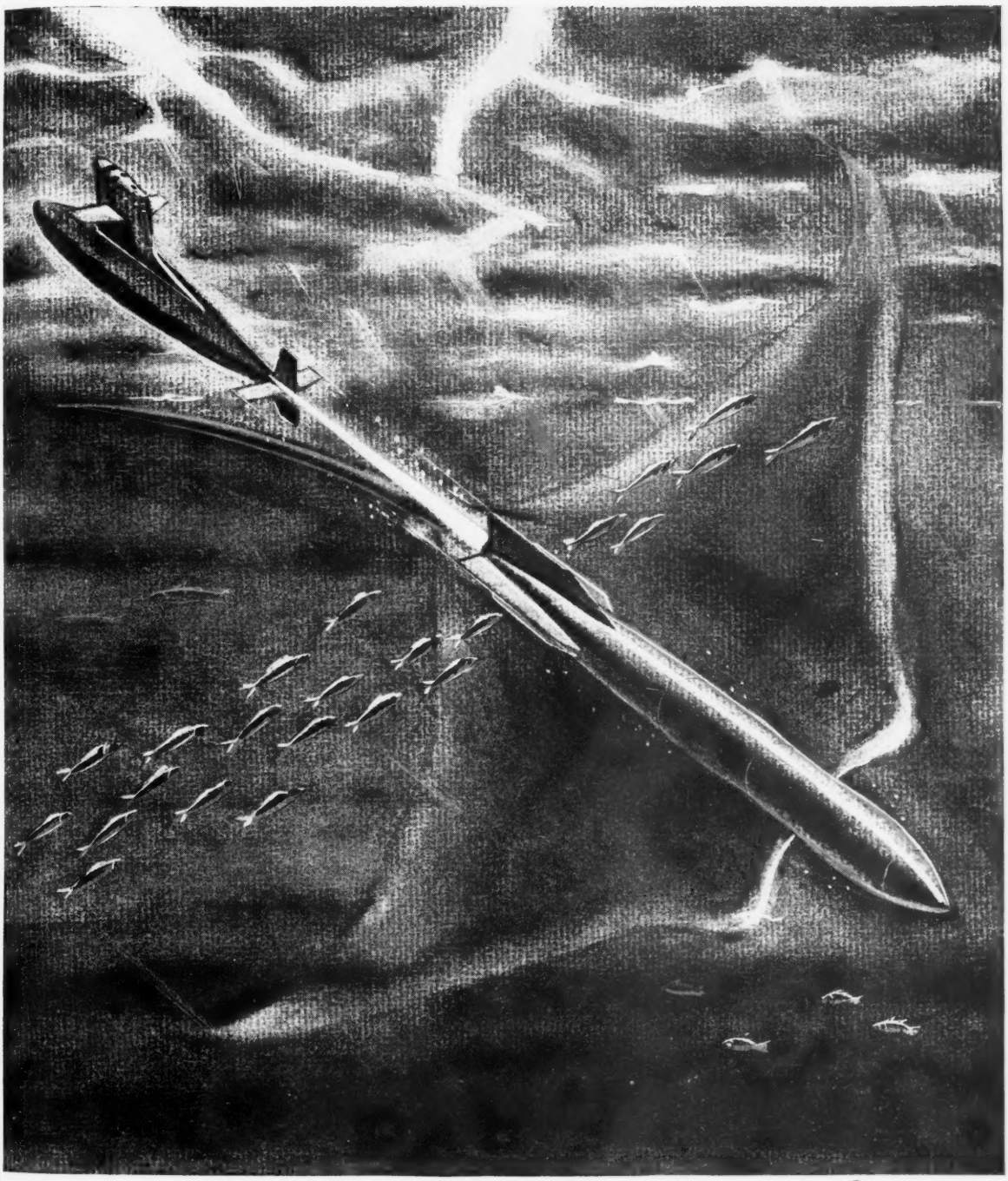
The principal requirement to be imposed upon the acceleration system for an ion-rocket is that the acceleration electrodes intercept a minimum of accelerated particles. This is nec-



Power for Ion Propulsion

In Lockheed Missiles and Space Div. plan, a nuclear reactor, as diagramed at left, would activate 200 thermionic cells arrayed as an outer cylinder to give an output of 1000 kw. This current would flow over a mile-long coaxial cable to spacecraft and power ion engine, as indicated in drawing below.





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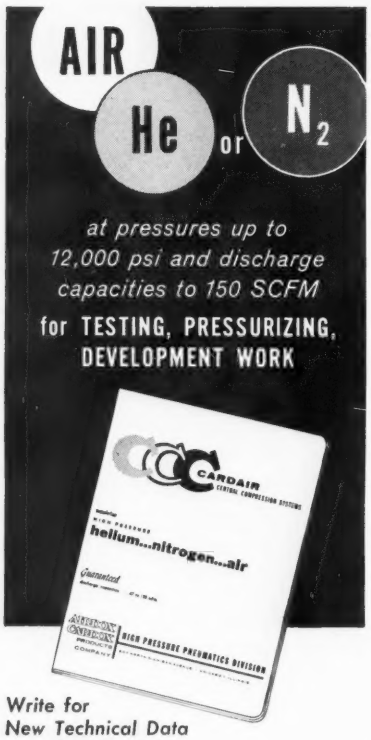

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Table 1—Characteristics of a Cesium Ion Source

Temp, K	Total Emissivity of Tungsten, ϵ_T	Power Radiated, watts/cm²	Cesium Ion Current at Critical Temp, ma/cm²	Power Radiated Per Unit Ion Current, watts/ma
1100	0.128	1.06	0.088	12.0
1150	0.135	1.34	0.308	4.35
1200	0.143	1.68	1.08	1.55
1250	0.151	2.09	3.24	0.645
1300	0.158	2.55	8.95	0.285
1350	0.167	3.14	23.0	0.136
1400	0.157	3.81	55.0	0.0693
1450	0.183	4.59	124	0.0370
1500	0.192	5.51	272	0.020

(See Reference 1)

essary to maintain high power-conversion efficiency and to minimize electrode erosion. Various types of simple acceleration systems have been proposed. These include Pierce guns, pinched beams, and simple divergent-field geometries. It is also necessary that the beam not be too divergent; otherwise, thrust losses occur.

It has already been mentioned that space-charge limitations on the maximum current densities which can be drawn from an ion source render low-I_{sp}, high-current density accelerators difficult to design. For example, a cesium-ion accelerator with a specific impulse of 5000 sec and an acceleration gap of 1 cm would be space-charge-limited to a current density of 0.300 ma/cm². The current densities attainable at low specific impulse can be increased either by decreasing the acceleration gap or by turning to an accel-decel acceleration system.

Accel-Decel System

The first method appears to be complicated only by the very small spacings required. With respect to the second method, it has been shown by Faye, Samuel, and Shockley[3] that, under the appropriate operating conditions, it is possible to extract large current densities from a source with high acceleration voltages, and then to decelerate these to the desired terminal voltage without any reduction in the current density. Such an accel-decel acceleration system has the additional advantage of preventing those electrons injected to neutralize the beam from flowing back to the positive ion source. A diagram of such a system is shown on page 98. Unfortunately, the accel-decel system suffers from certain problems concerned with its ion optical aberrations and its greater susceptibility to power losses and erosion at the high voltage acceleration electrode.

Future accelerator development efforts may be directed toward:

1. The development of better analytical approximations to charged-particle and charged-fluid flow.

2. The development of analog and digital computer representations of space-charge flow to permit computer design of ion accelerators.

3. Experiments with actual thrust-device ion sources. Some attention should be given to the clustering of ion-rocket motors, since clustering seems to be imperative for actual space propulsion.

4. The problem of electrode erosion. A compilation of the existing sputtering and erosion data would be a necessary first step.

5. While most of the present investigations are not afflicted with high-voltage breakdown problems, these problems may arise when small-gap, high-field accelerators are sought which will operate for extended periods of time.

One of the most pressing unanswered questions regarding ion-rockets is that of space-charge neutralization. Two methods for accomplishing this result have been proposed. One of these consists of injecting electrons directly into the beam. Another utilizes the phenomenon of charge exchange by promoting the interchange of an electron between the charged ions and a spray of neutral atoms pro-

Table II—Work Functions and Melting Temperatures of Various Metals

Metal	Work Function (Photoelectr), eV	Melting Temp, C
Ag	4.7	960
C	4.81	3550
Cr	4.37	1890
Ir	4.9	2454
Mo	4.3	2620
Os	4.5	2700
Pt	5.2	1773
Re	5.1	3167
Ta	4.1	3027
W	4.4	3370

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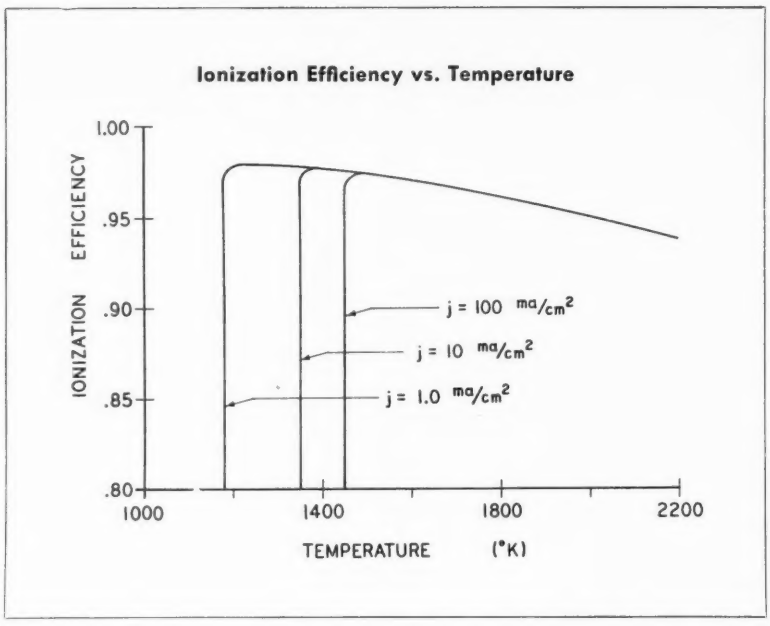


jected across the beam. However, both of these solutions are still unproved.

It may be thought that it is necessary only to provide electrons to the beam and that, because of their vastly higher mobility, the electrons will recombine or will distribute themselves in such a manner as to eliminate any net space charge. However, the probability of volume recombination or even of electron scattering in ion beams with particle densities of $10^{10}-10^{11}/cm^3$ is vanishingly small.[4]

Furthermore, calculations indicate that the electrons will oscillate transversely across the beam, leading to poor beam neutralization and large positive potentials at the center of the beam. Since, to first order, the electrons lose no energy in traversing the beam, and since they must be emitted outside the beam to avoid filament erosion, the electrons oscillate between equipotential surfaces lying outside the beam. The poorly neutralized ion beam will eventually encompass the electrons because the beam will diverge laterally as a result of mutual repulsion between the ions. However, the equipotential surfaces between which the electrons oscillate also tend to expand with the beam. In addition, it can be shown that even if a plasma could be established in the beam at one time, it would not be selfsustaining.

Other possibilities leading to the formation of a neutral plasma do exist. There is some theoretical indication that "standing waves" across the beam are possible with space-charge-limited electron currents. If these higher-order-mode solutions to the equations of space-charge flow should be the preferred modes, great reductions in the beam potential would occur.

It may be asked why it is not sufficient to simply eject the ions and electrons in equal numbers. Why does it matter whether the electrons and ions mix uniformly immediately behind the ship? Also, why is it necessary to know what happens during this mixing process?

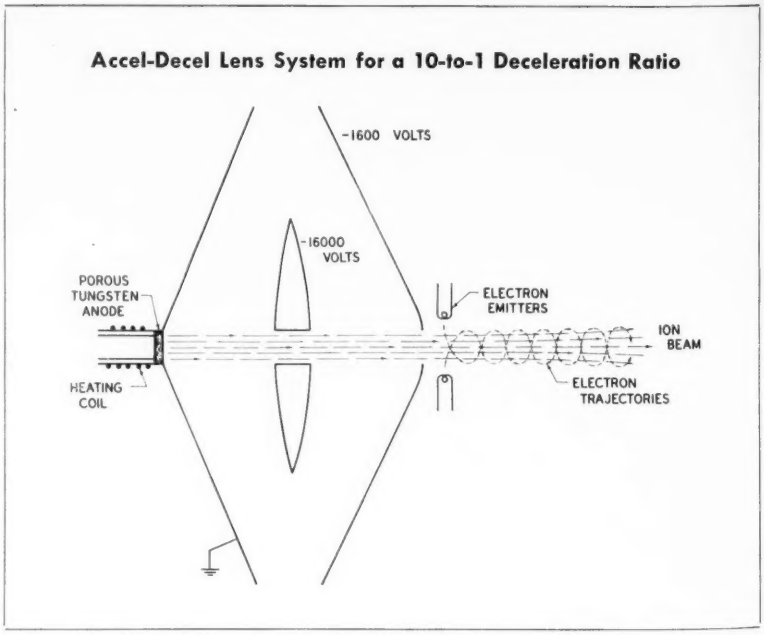
The answer is that, since the electrostatic forces accelerating the positive ions are conservative forces, the ions leaving the cathode region will lose whatever kinetic energy they have gained in falling into the cathode region unless the positive space charge is neutralized while still in this region. Also, the space-charge-generated fields behind the ship exert a strong perturbing influence on the design of the electrostatic lens system that focuses the beam. Further, the space-charge clouds behind the ship can exert field-forces on the ship in a manner which has no counterpart with chemical rockets. As a result of these image forces, a thrust loss will result from lateral expansion of the beam arising from unneutralized positive space charge. This will reduce both the power and mass-utilization efficiencies. Additional wasted energy will be associated with the electron oscillations. This can also constitute a powerful source of electromagnetic noise.

Possible future ion-beam neutralization studies should consist of:

1. Immediate experimental studies. One of the experimental studies conducted to date has indicated a high degree of neutralization, while other investigations have pointed toward less favorable results. In all these experiments, precautions must be taken to insure that gas focusing and the finite boundary conditions which exist in the laboratory do not invalidate the extrapolation of laboratory results to actual space conditions.

2. Experimental studies of charge-exchange neutralization.

3. Theoretical studies of beam



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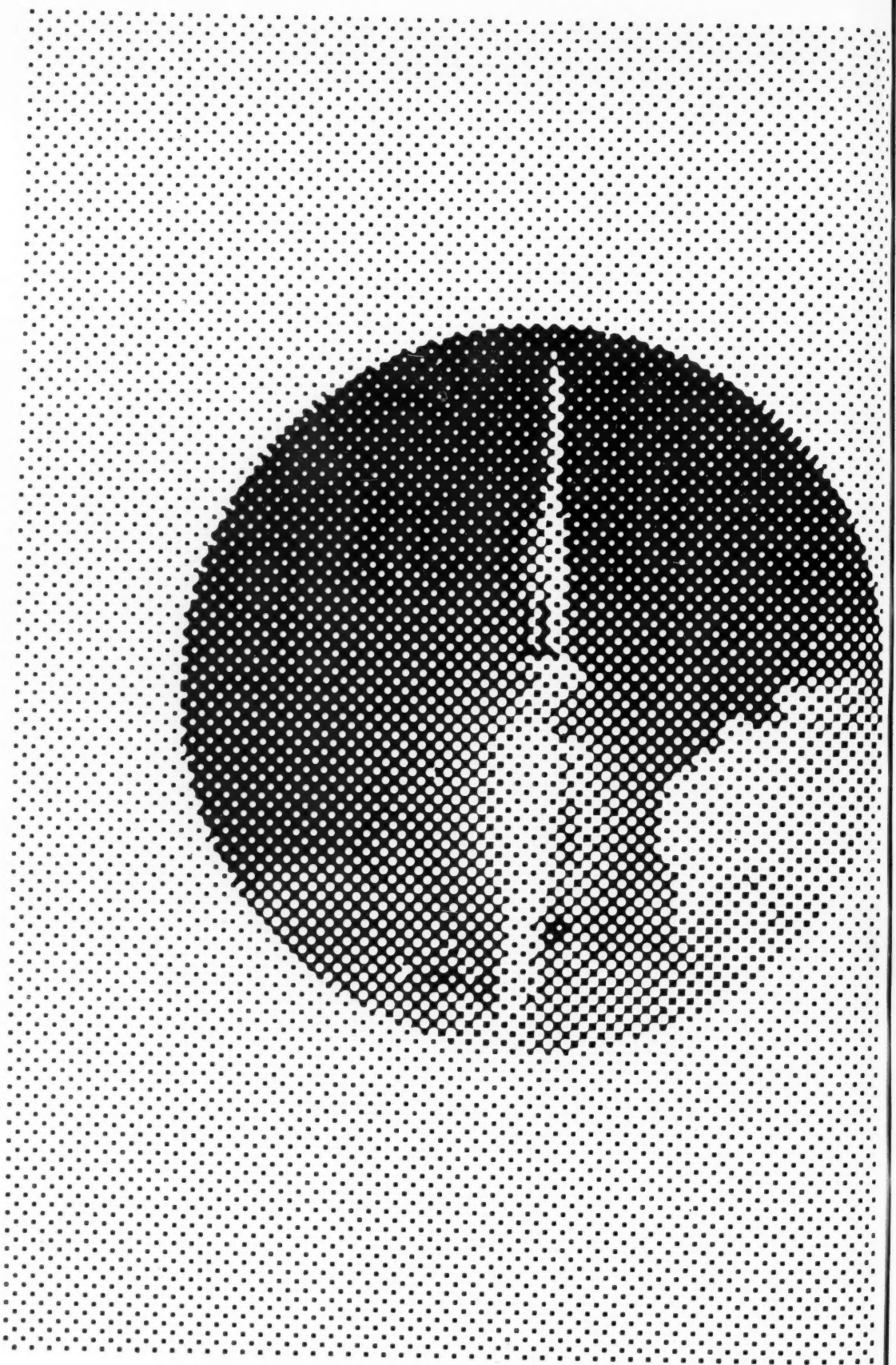

There are 7,500 dots shown here.
This is the number of engineers in the eight divisions of Martin. And 40 percent of these—the 3,000 dots in the circle—are electronics/electrical engineers.
It is this specialized capability that enables Martin to develop electronic systems which anticipate the exacting demands of the missile-space age.
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The eight divisions of The Martin Company are Activation, Baltimore, Cocoa, Denver, Nuclear, Orlando, RIAS, and Space Flight.

neutralization, drawing upon the aforementioned experimental results. This would include network and electrolytic-tank computer studies.

Future Role Promising

The promise for the future is very great. Theoretically, ion-rocket motors should be able to provide power and mass-utilization efficiencies approaching 100 per cent, useful lifetimes of several years, and thrust-to-weight ratios which render a variety of space missions not only feasible, but more economical than if they were flown with chemical propulsion systems. Since the theoretical limits of ion-engines have not yet been closely approached, further order-of-magnitude improvements in ion-motor performance appear likely in the near future.

References

1. Kuskevics, G., *Rocket Efficiency Studies* (Table 1); a paper presented at the 10th IAF Congress, London, 1959.
2. *Handbook of Chemistry & Physics*, 37th ed., 1955-56; Chemical Rubber Publishing Co., Cleveland, Ohio.
3. Faye, Samuel, and Shockley, "On the Theory of Space-Charge Flow Between Parallel Plane Electrodes," *Bell System Tech.*, Jan 17, 1938, p. 49.
4. Massey, H. S. and Burhop, E. H., *Electronic and Ionic Impact Phenomena*, Oxford at the Clarendon Press, 1956. ◆◆

Physics

(CONTINUED FROM PAGE 43)

subject of the density of the high atmosphere. Despite this interest, considerable speculation still remains concerning density problems.

Some of the more important work accomplished has been in experimental work on the solar ultraviolet spectrum and in Lyman-alpha observations. The whole problem of the physical chemistry of the upper atmosphere and near-space has been receiving increased attention.

Other Investigations

These might be called the spectacular or "attractive" fields of current interest. However, investigations are also starting or continuing in more routine aspects. Problems such as auroral phenomenology, turbulence at very great height, and "thermal" radiations from planetary bodies have been continuing at an increased pace. All of this adds to the storehouse of knowledge concerning the upper atmosphere and space.

We can look forward during the next year to an increase in activity in all areas. ◆◆

In print

Space Handbook by Robert W. Buchheim and the staff of the Rand Corp., Random House, New York, 1959, 330 pp., illus. $3.95.

"The report. . .represents the most comprehensive unclassified study on the subject (of astronautics) now available. The report is confined to technical and scientific analysis, avoiding expressions of opinion on policy and administrative matters. It studiously avoids borderline speculative judgments on the pace of future developments."

The above quotation is part of a special resolution passed by the House Select Committee on Astronautics and Space Exploration commending the "Space Handbook," prepared for it late last year by Rand Corp. to fulfill a need felt by the Committee for "an authoritative study in lay terms which would set forth clearly the present and definitely foreseeable state of the art of spaceflight."

It provides a perfect description of what is unquestionably the most outstanding work of its kind to date. Random House has performed a public service in making it available in this updated hardcover edition at a comparatively low cost. It is deserving of a place in the library of anyone with an interest in astronautics.

Written in straightforward, factual style, and profusely illustrated, it covers in logical sequence every aspect of astronautics, beginning with a brief history of the subject, proceeding to a full-scale analysis of space technology and applications, and concluding with a rundown on astronautical activities in other countries.

While it would obviously be impossible to run through everything covered in the book, a brief look at the 160-page section devoted to astronautical technology will help suggest its comprehensiveness. The section begins with a look at the space environment and proceeds to an analysis of trajectories and orbits. Next comes a rundown on rocket vehicles, propulsion systems, and propellants. This is followed by an examination of internal power sources and structures and materials. Then come problems involved in flight path and orientation control, guidance and communication, and observation and tracking. Next, a look at atmospheric flight, landing, and recovery, followed by sections devoted to the environment of manned space systems, space stations and extraterrestrial bases. The effects of nuclear weapons in space come in for discussion next. Then comes a section on cost factors and ground facilities, and, finally, a rundown on current developments.

The 100-page section on space applications is every bit as detailed, beginning with an analysis of various missions; proceeding to full-scale examinations of observation, meteorological, navigation, and communication satellites; and concluding with a rundown on scientific space exploration which includes a look at experimental programs now in progress or contemplated.

The jacket blurb for "Space Handbook" states that it will be "the last word, for some time to come, on space and its exploration." For once, a publisher is not exaggerating.

—I.H.

Spaceport U.S.A. by Martin Caidin, E. P. Dutton, New York, 1959, 380 pp., illustrated. $4.95.

In this, the first full-scale report on Cape Canaveral and the AF Missile Test Center, Martin Caidin, the most prolific writer in the astro-aeronautical field today (eight books in two years) turns his attention to the free world's largest missile and space vehicle launching facility. The result is a fascinating account of the men, the vehicles, and the physical facilities of this vast laboratory of the space age which will be as interesting to the astronautical engineer and scientist as it is to the layman.

Scarcely a single facet of the great complex of facilities which make up AFMTC and the Cape has been neglected. Here you will find a fascinating history of the Cape going back to 1895, full-scale physical descriptions, dramatic eyewitness accounts of the firing of research rockets, ballistic missiles and space vehicles, complete details about facilities and instrumentation of various kinds, and of the people at the base, their daily life and their work.

Nor is this all, for the author has also treated a number of subjects which he, as a writer, has found to be of interest. Here, for the first time, for example, is a detailed description of the censorship problem at the Cape and how it was finally solved. Two chapters provide full-scale analysis of the different approaches taken by the Army and the Air Force to the problem of designing and building long-range missiles and space vehicles. One background chapter even contains the fascinating suggestion that the V-2 may have cost Germany the war.

Adorned with more than 40 excellent line-drawings by Bert Tanner and a profusion of excellent photographs, this new Caidin effort constitutes the definitive work to date on the Cape and what makes it tick.

—I.H.

Russia and the Big Red Lie by Lloyd Mallan, Fawcett Publications, Greenwich, Conn., 1959, 144 pp., profusely illustrated. $0.75.

This book, a condensed version of which was first published earlier this year in *True Magazine*, is the product of a two-month, 14,000-mile junket by the auther and his wife through Russia to determine how far ahead of the U.S. the Russians are scientifically. The trip was sponsored by the editorial executives of Fawcett publications for the purpose (1) of getting "a first-hand report by an accredited science writer traveling as an ordinary American citizen, not as a member of government, not as a ranking officer of the armed forces, not as a scientist associated with an official organization"; and (2) of securing "an honest, unbiased picture of Russian achievements in the space field and report them as such." Say the editors: "If Russian science was indeed years ahead of American work, it had to be so reported." The book is dedicated to Larry Eisinger, editor-in-chief, "for many important reasons which are best known to him."

The book is prefaced with a one-page biographical sketch of the author, a three-page editorial "apology" entitled "How This Book Came About," and a two-page map of the author's itinerary through the Soviet Union, including a list of the 15 strategic points visited and the names of 40 Soviet scientists, 38 of whom were interviewed by the author. The author has divided his account into four parts, which the table of contents labels: (1) The Lunik Hoax; The Soviet Spaceflight Program; (2) The Nonexistent Russian ICBM; Soviet Missiles and Rockets; (3) The Myth of Soviet Airpower; and (4) The Four Faces of the Big Red Lie.

About 200 photographs illustrate the book, half were either taken by the Mallans themselves in the U.S.S.R. or selected from Soviet sources, and half

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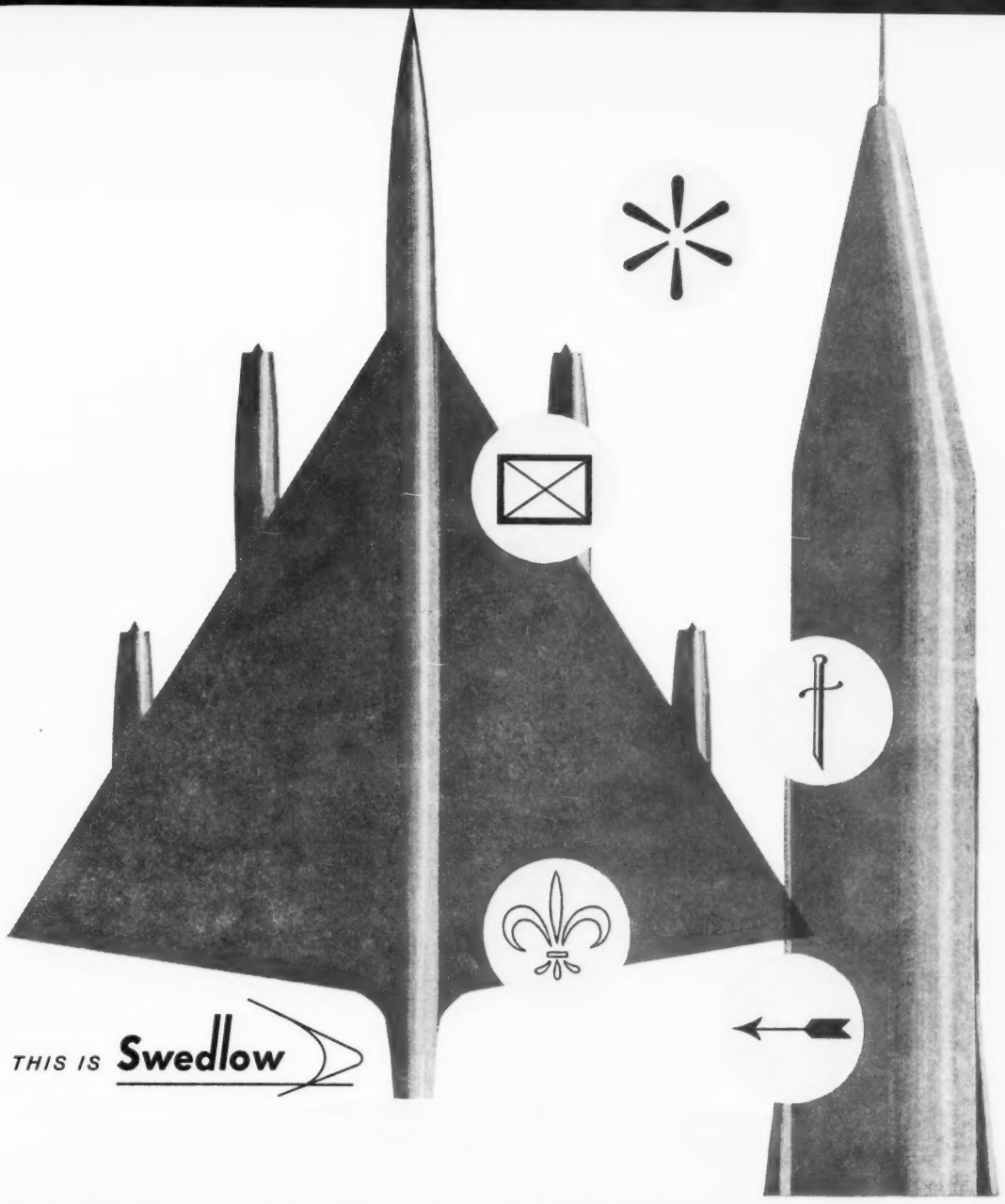

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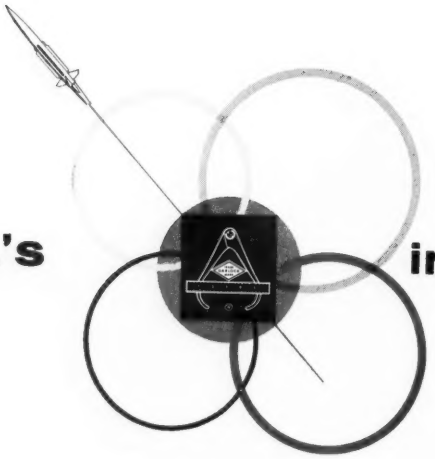
How Garlock's  **integrated**

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- **Polaris**
- **Minuteman**
- **Nike Hercules**
- **Terrier**
- **Super Tartar**

Missile market

BY JEROME M. PUSTILNIK, Financial Editor

IN the last month the Dow-Jones Industrial Average tumbled 7.1 per cent before rallying to cut its loss to 4.7 per cent; the Missile Index declined for the fifth consecutive month, dropping 6.4 per cent. General Precision Equipment and Raytheon, with gains of 50¢ per share, were the only Missile Index companies on the upside.

Unsettlement over the Khrushchev visit and the dislocations caused by the lengthy steel strike have been most frequently mentioned as reasons for the market slide. In the missile sector, talk about disarmament and contract cancellations (high-energy fuels and F-108 programs) continue to be blamed for its weakness.

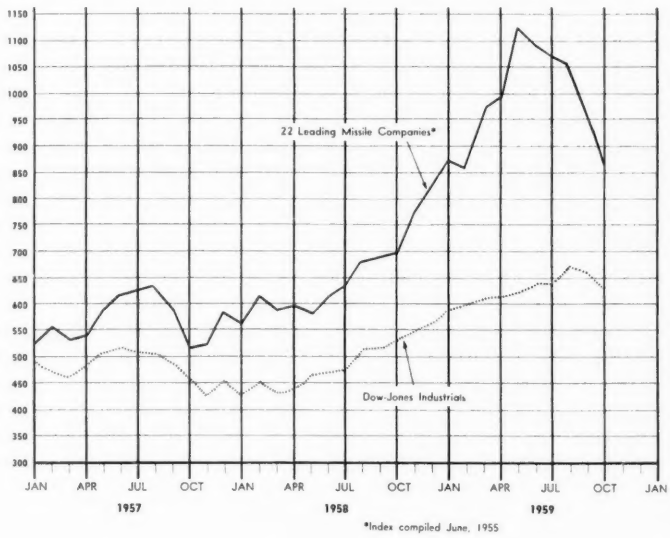
Even as the Soviets impacted on the moon, this weakness continued–vivid contrast to the heady upward spiral into which missile securities took off when the first sputniks were orbited, two short years ago.

As interesting as these explanations of past stock market behavior may be, it is 20/20 foresight, not hindsight, investors are seeking. This column believes the nation's robust economic health has been impaired by the maladies of tight money and labor-management strife. Though the economy appears vigorous enough to assure recuperation, some strength has been sapped from it and caution is definitely advised. Investors should review their securities, check whether earnings are in good health, and see if market prices are reasonable in relation to earning prospects.

In examining the missile market, total expenditures for the coming fiscal year seem likely to hold at about present levels, despite the clamor for more money for new programs and maturing projects. To bring supply and demand into better balance, the Pentagon may negotiate more R&D awards at the expense of production contracts; and it may cut back or cancel some programs to supply funds for more promising projects.

With these thoughts in mind, Garrett Corp. seems an attractive investment at this time. Reasonably priced in terms of earnings, and relatively insulated against cutbacks and cancellations through its participation in about 30 different missile programs (not to mention important aircraft and commercial business), Garrett has enjoyed excellent sales growth since the end of World War II. Revenues, which were only $15.5 million in 1946, reached a record $193.6 million in fiscal 1959.

THE MARKET AT A GLANCE



*Index compiled June, 1955

	October 1959	September 1959	% Change	October 1958	% Change
Dow-Jones Industrials	632	663	−4.7	527	+20.0
Missile Index	870	929	−6.4	694	+25.5

Net income per share grew almost as lustily–from $0.58 to $4.61–despite a near 100 per cent increase in the number of shares outstanding. These gains reflect Garrett's continuing effort to increase its share of the total military aircraft and missile procurement dollar. For example, while total spending for major military procurement and production have increased 367 per cent since 1951, Garrett's total military sales rose 600 per cent.

The company functions through eight operating divisions. AiResearch Mfg. Co. (Los Angeles) produces aircraft and missile components and component systems, including cabin air compressors and pressure controls; air data computing systems; air-conditioning, refrigeration, and electromechanical equipment; auxiliary power units; heat-transfer products; ram-air turbines; temperature controls; and instruments and gauges. AiResearch Mfg. Co. (Phoenix) produces pneumatic valves and controls; turbomachinery products including gas turbine engines, air turbine starters, and air gas turbine motors; and nuclear and other advanced experimental products in the field of missiles and aircraft.

AiResearch Industrial Div. produces high-performance turbochargers and boost pressure controllers for heavy-duty diesel engines; industrial type valves and other related products for the diesel industry. Air Supply Co. is the sales and engineering representative for suppliers of aeronautical and industrial products (which are not competitive with Garrett's) in the west, while Aero Engineering does the same job in the east; both divisions offer extensive branch office coverage. Garrett Supply Co. is a distributor of general tools and industrial supplies, rendering specialized engineering services to customers.

AiResearch Aviation Service designs and installs custom business aircraft interiors and special aeronautical equipment; and rebuilds, modifies, and maintains aircraft for airlines, the mil-

(CONTINUED ON PAGE 164)

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In print

(CONTINUED FROM PAGE 102)

from Western sources (mostly American). For the most part, the photographs are arranged so as to demonstrate the "primitive" nature of Soviet equipment in comparison with modern American equipment.

Reading "Russia and the Big Red Lie" calls to mind a celebrated line from Shakespeare's Hamlet (Act III, Scene 2): "The lady doth protest too much, methinks." In this case, it is Mr. Mallan who protests too much by overly decrying Soviet capabilities and achievements in science and technology—particularly in space technology—and disparaging the opinions of American scientists in support of Soviet claims.

After his two-month mission in the U.S.S.R.—seeing and hearing only what the Soviets permitted him to see and hear—Mr. Mallan was thoroughly convinced that "The Russia I knew was not capable of designing or building an effective intercontinental missile—or, indeed, any long-range rocket that would know where it was going before it got there. This Russia was a good 20 years behind the U.S. in space technology." This despite three Sputniks with their extensive, if unsophisticated, instrumentation!

That Mr. Mallan was not very well prepared for his mission is quite evident. He was armed with letters of introduction "to prominent Soviet scientists from their equally prominent counterparts in the Free World." He was mildly acquainted with material published in a small segment of the Soviet popular-science press. But he was unaware of a considerable body of information published in technical journals by Soviet space scientists months before he made his pilgrimage to the U.S.S.R.

Mr. Mallan was also naive enough to believe that he could elicit from the Russians quasisensitive information about their missile and space program—information that qualified Western scientists have been unable to obtain at various international conferences. The following example will illustrate what happened to Mr. Mallan because of his inadequate preparation.

One of Mr. Mallan's "key interviews" was with Prof. Gleb Chebotarev, director of the Institute of Theoretical Astronomy in Leningrad, who early in 1957 had published in the Institute's Bulletin a paper entitled "A Symmetrical Rocket Trajectory for Flight Around the Moon." A popular version of this paper, entitled "Cosmic Boomerang," appeared in the February 1957 issue of the popular-science magazine *Znanie-Sila* (Knowledge Is Power), with which Mr. Mallan is acquainted. The Soviet press, according to Mallan, widely touted Chebotarev as the head of "Project Boomerang," a planned effort to send a rocket around the moon. When Mallan asked Chebotarev how close the project was to its goal, the answer was "I cannot say. I have not yet been approached by the engineers."

This statement must have convinced Mallan that the Soviets were not even planning a lunar rocket, for he wrote: "The launching of a lunar probe (or solar probe, as the case may be) must also be planned very carefully in advance. No such plan existed when I was in Russia half a year before. One lonely professor had made the basic mathematical calculations for the idea. No one else seemed actively interested, according to his own statement."

What Mr. Mallan did not know—but should have known, and Prof. Chebotarev did not volunteer to tell him, even though it was common knowledge—was that a very extensive study of earth-moon rocket trajectories had been underway since 1953 at the Steklov Mathematics Institute in Moscow. A summary report by V. A. Egorov, entitled "Some Questions on the Dynamics of Flight to the Moon," appeared in *Doklady Akademii Nauk SSSR* (Reports of the U.S.S.R. Academy of Sciences) of March 1, 1957, in which Egorov stated that more than 600 trajectories had been computed. Later, a comprehensive report by the same author, "On Some Problems of the Dynamics of Flight to the Moon," was published in the September 1957 issue to *Uspekhi Fizicheskikh Nauk* (Progress in the Physical Sciences).

Reprints of this report were distributed to the participants of the Eighth International Astronautical Congress in Barcelona in October 1957, about the time that Sputnik I was launched. Copies of this report, and several others dealing with astronautics, were in the hands of some of the scientists who wrote Mallan's letters of introduction!

Mallan's case for the nonexistence of the Soviet interplanetary rocket Mechta (or Lunik, as it is commonly called) is based on his belief that the signals received by the NASA's Goldstone tracking station (the only station in the Free World to track the vehicle) were questionable and therefore inconclusive. He thus impugns the veracity of sworn statements by leading American space scientists before the U.S. Senate Committee on Aeronautics and Space Sciences (Jan. 29 and 30, 1959). Readers may recall that shortly after the appearance of the May issue of *True Magazine*,

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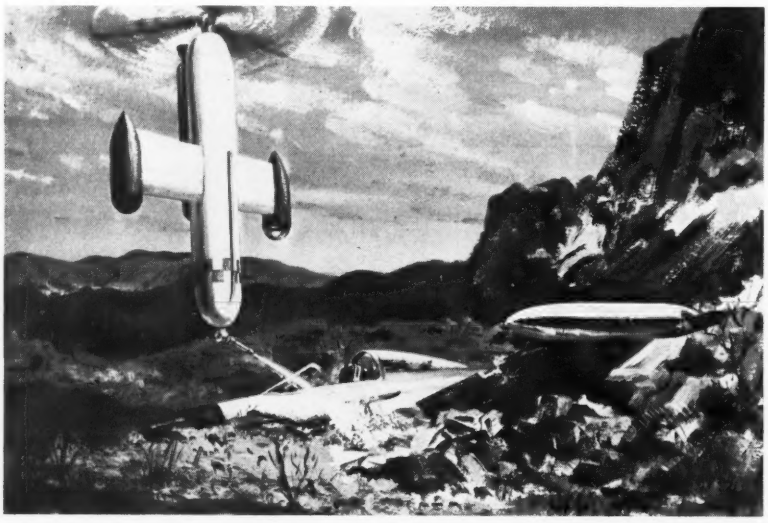

Fire Engine You Can't Chase

This sketch shows a rocket-boosted remote-controlled firefighter proposed by Solar Aircraft to reduce time in reaching crashed aircraft. Able to cover 5 miles in 40 sec, the so-called Firefly would hover by means of a helicopter engine and deluge fire with as much as a ton of extinguisher. Radar and infrared-seeking equipment in the Firefly would, through telemetered data, allow a base operator to pick place, direction, and amount of extinguisher discharge remotely.

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Recently developed magnetic devices are being combined with new principles of circuit logic to yield advanced electronic systems at the IBM Federal Systems Division. Ceramic ferromagnetic wafers provide computer designers with components that are small, versatile and extremely rugged. Used as logical connectives in computer circuits, these solid state devices will make possible more capable computers of greatly reduced size. They will serve with the high degree of precision and reliability essential to military applications. At IBM, a major team of systems engineers is fulfilling national defense requirements for all types of information handling systems. Complete facilities for: **Research • Development • Manufacturing • Testing • Product Support • Systems Management.**

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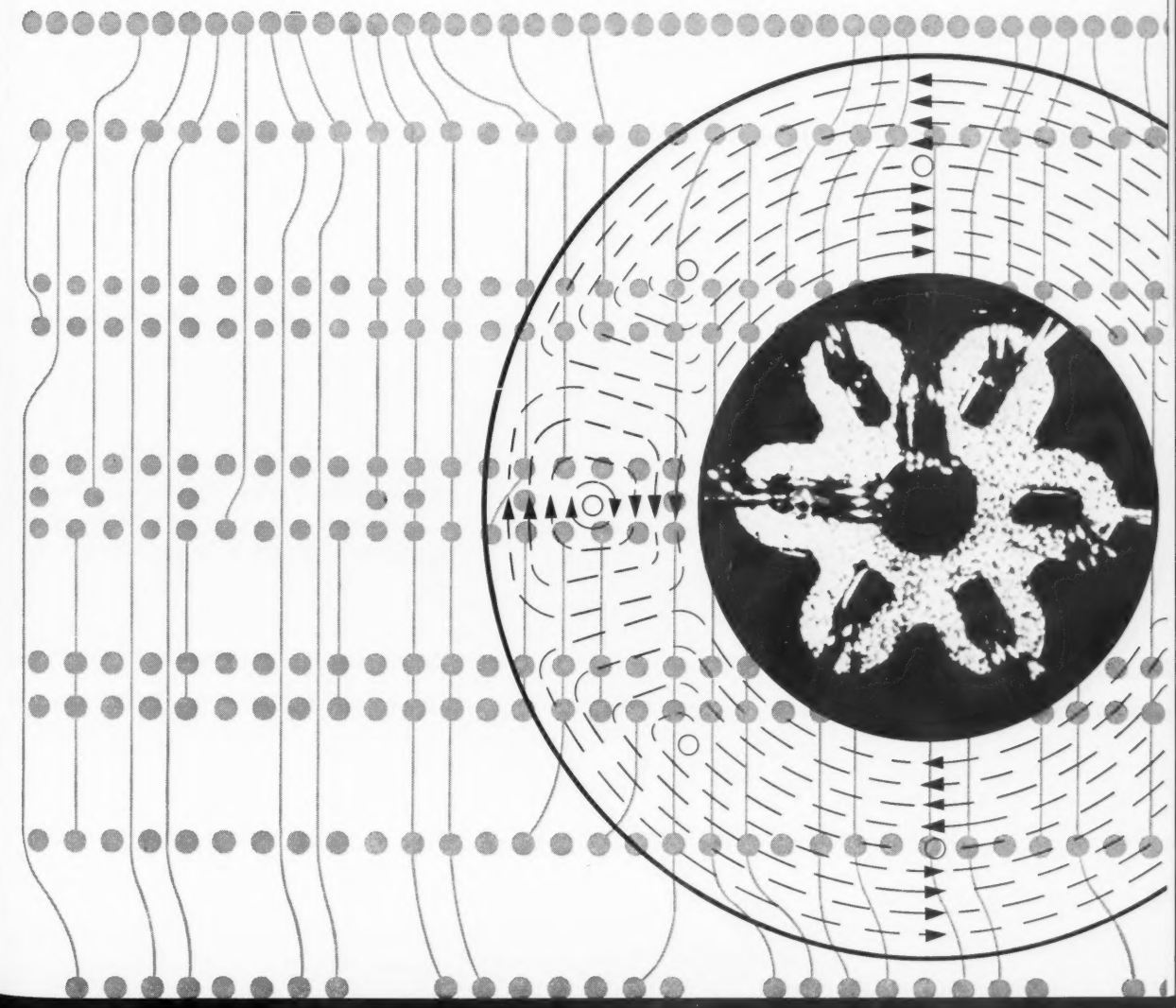
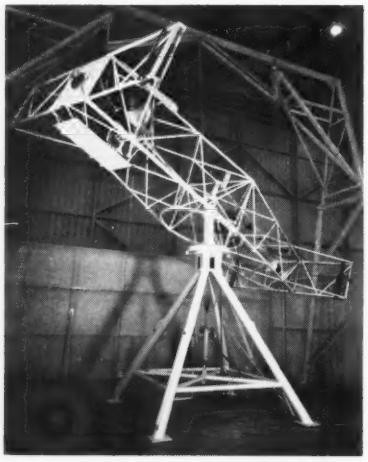


Boeing Space-Motion Simulator



Riding on a near-frictionless air bearing, this reaction-control simulator, designed by Boeing engineers, tests methods for controlling attitude of a space vehicle. Either pilot or automatic system can control the simulator.

Military Space Program

(CONTINUED FROM PAGE 27)

Furthermore, the Secretary of Defense has announced a plan for the eventual transfer of four space projects in the final stages of advanced research under ARPA to the Military Departments for operational development. These projects include Samos and Midas (AF), Transit (Navy), and Courier or Notus (Army). Further decisions will be required as to the dates for transferring these projects from ARPA responsibility.

This year, ARPA controls projects in military space technology costing some $400 million, distributed approximately as follows:

Advanced reconnaissance systems	30%
Defense alarm space vehicles	15%
Flight-development of critical space-vehicle components, vehicle development and ground support	35%
Military support missions, e.g., communications and navigation	15%
Feasibility studies and exploratory research	5%

Below are some of the details of several of the more significant projects, all of which are in their early stages.

Discoverer

This project covers the systematic probing of the space environment by means of satellites. Such probes require a wide variety of apparatus and techniques to provide us with the knowledge essential to military space programs.

Using a Thor booster and an Agena (Lockheed) upper stage with a storable liquid-propellant rocket (Bell Aircraft) engine, and with a recoverable capsule, the Discoverer was first launched in February of this year. Several more experimental launchings have since been carried out. Its primary purpose is to serve as a space-based research and development tool for exploring new concepts, components, and fundamental problems. For example, it provided information on attitude control, ground communication, capsule ejection, recovery methods and techniques, biomedical experimentation, research of special fundamental problems, and satellite trajectory determination. The development of the upper Agena stage has direct application to other space vehicles using this stage. Next year a number of additional Discoverer launchings are planned from the Pacific Missile Range (PMR).

Advanced Reconnaissance Systems

Continuous inspection of the earth's land areas would do much to insure against surprise attack and provide time for the alerting of retaliatory forces and for activating passive civilian defenses. This capability is being explored by ARPA under Project Samos.

Midas

Just as ancient armies were warned by the campfires of their enemies, we will be warned of aggression by the Missile Defense Alarm Satellites' detection of the infrared rays radiated by the flame of ICBM's launched by an enemy. Such early warning will make it possible to initiate measures to keep the missiles from reaching their targets.

Midas (Missile Defense Alarm System) is a satelliteborne missile alarm system development which uses infrared for the detection of enemy ballistic missiles and a solar radiation system for long-life auxiliary power. The early warning which is possible with such a system will permit rapid initiation of active and passive defense measures. A series of polar orbits, and use of the Atlas-Agena vehicle combination is planned. In the next year, a few experimental launches using low orbits and experimental components will be accomplished.

Transit

This fulfills an operational need for global, precise all-weather navigation. The use of satellites for navigation is based on the strong similarity between accurately known satellites and the stars which have been the traditional foundation of precise navigation. However, a satellite can be equipped with a radio to broadcast its location. Using the Doppler radio technique, Transit determines the position of a receiving station on a ship, submarine, or airplane with reference to the point of nearest approach of the satellite. The eventual satellite could carry its own ephemeris to improve initial accuracy and convenience. Thor-Delta vehicles are scheduled for launching during the next year.

Communication Satellites

The need for a reliable, all-weather, instantaneous, and jamproof military communication system is an old problem. The eventual solution will use three to four carefully spaced satellites in equatorial 24-hr orbits and will provide broadband, microwave communications by direct line-of-sight transmissions to all parts of the globe. Studies and component development of this system are planned for next year. Its application is in communication between ships, submarines, aircraft, military bases, and military installations.

As an interim experimental system, the Courier satellite will provide active repeater relay communications experiments. Messages received by the satellite will be stored on tape, and upon a command signal this information will be rebroadcast rapidly as the vehicle passes over the receiver ground station. It will be capable of providing 20 one hundred word-per-minute teletype channels of worldwide communication. For the Courier launchings next year, several Thor-boosted flights are planned.

Saturn

Beyond 1962, we will require the launch vehicles for putting ten tons (or more) into moderate altitude orbits, and two tons (or more) into very high orbits.

The Saturn will fulfill these requirements. It uses a cluster of eight engines and an array of modified Redstone and Jupiter tanks as the booster, a slightly modified Titan as the second stage, and a Centaur as the third or upper stage. The booster engine cluster gives a thrust of 1,500,000 lb, and use of existing proved components is expected to enhance the reliability

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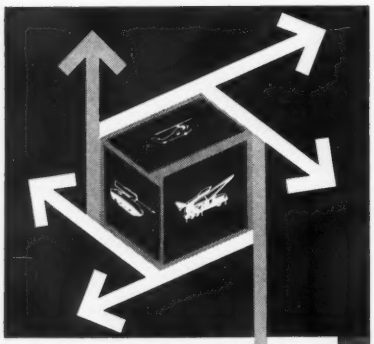

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of this vehicle. Booster engine design permits the nondestructive failure of one of the eight engines without the loss of the mission. The cost of a pound of payload in space will be appreciably reduced in the Saturn as compared to other vehicles.

Eventual applications of the Saturn include advanced communication satellites, defensive satellites, and various manned spaceflight missions. During 1960, static-tests on the booster system will be accomplished and work on the modification of the Titan second stage will be initiated.

Tracking and Data Acquisition

As time goes on, there will be many satellites in orbit at any one time. Some of these will give out radio signals or other radiation; others will be silent. ARPA has been assigned the task for formulating for DOD a tracking and data readout system to locate, track and provide various data on military satellites, both those launched in the U.S. and those launched by other nations. For the detection of satellites there is a detection "fence" network for radiating as well as for silent satellites.

The construction of this system is almost completed and it will become fully active during the next year. Data will be fed to a central station for reduction and transmission to interested organizations. In order to assure effective utilization of all of these tracking and data acquisition facilities, an agreement has been reached between NASA and DOD on joint implementation and use of worldwide space tracking, data acquisition, and communications networks.

Feasibility Studies

The investigation of new concepts and possible novel spacebased weapons systems and their major subsystems is being carried on in a series of studies. These feasibility studies will help us decide what we can and should do in military space activities.

The concept of a maneuverable, recoverable space vehicle (nicknamed Project MRS-V) is one example of such a study. This vehicle can fulfill missions of direct defense or deterrent use. These require the capability to maneuver freely in space, to return from orbit and to land under full control, whether manned or unmanned. The military implication for other missions are not clear today, but will evolve as our studies progress.

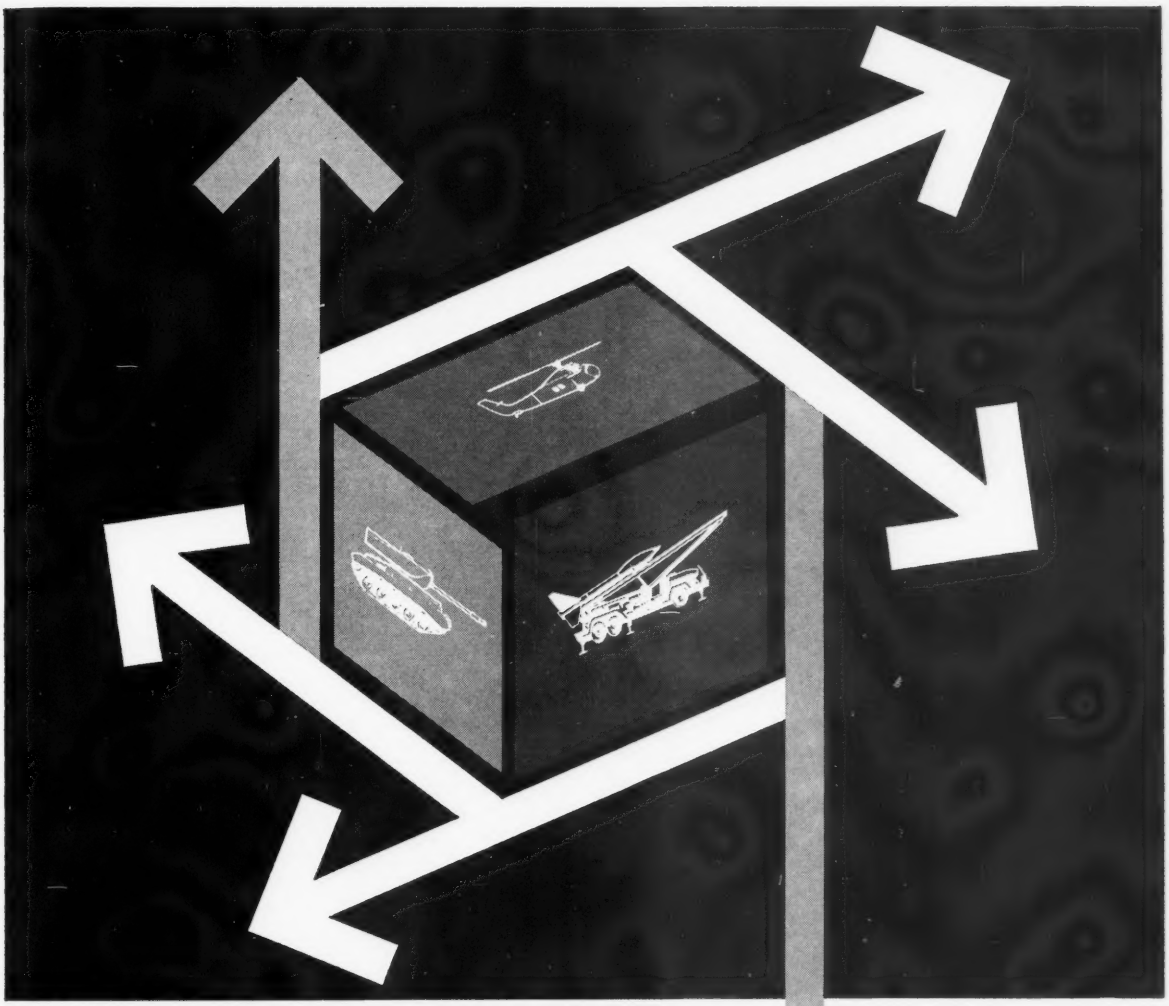
Exploratory Research

The exploratory research and development program carried out by DOD in support of space technology for the most part is fundamental in nature and is aimed at advancing our knowledge in those areas of technology and science that could be helpful and may be vital to our future military space program. Among the research projects which are or will be pursued within a year are: Ion propulsion for space power, lightweight devices for optically concentrating the sun's energies, many different ideas on auxiliary power for military space applications, the conversion of energy by means of thermoelectric or thermionic devices, materials and structures urgently needed in building and designing vehicles and payloads for short and long-term operation in the space environment, re-entry physics, and a nuclear-propelled rocket.

Some of this work is very basic, such as the study of the interaction of phonons with phonons and holes with electrons. This work relates to the transmission of energy to various materials, particularly semiconductors, and has application to thermoelectric devices which are used for converting radiating heat from the sun into electrical energy for various space-vehicle power applications. The advancement of knowledge gained from this effort, for example, may very well yield new understanding of certain materials and reap great benefits in transistors, semiconductors, and other technology. Some of the exploratory research carried out in fields other than space technology, as for example, in ballistic missile defense, are providing us with research results that are directly applicable to this field, such as our work in advanced radars, data processing, and ballistic missile interception.

Many of the good ideas DOD is now using in the area of space technology have come from people in industry, research laboratories, and universities. We are constantly on the lookout for good ideas and novel approaches that can be applied toward improving our military space capabilities in this new and complicated technology. This article has described a number of space projects which have military potential and for which DOD has a need and/or a requirement.

We know how little we actually know and of the tremendous costs involved in gaining new knowledge. We are even more aware that this new element, in which we plan to operate, poses many new difficulties for military activities and makes possible solutions of old and new military problems. We know that this element will be exploited for military purposes by other nations and that we must be equally or more capable of operating in space if we are to protect our way of life. ◆◆



How to put wings on a warehouse

Giving overseas air bases what amounts to local warehouse service on important parts is an Air Force objective. Its present system has slashed delivery schedules up to *20 times*... saved taxpayers several *billion* dollars over the past decade. To improve it further, Douglas has been selected to develop specifications for a comprehensive Material Handling Support System involving better communications, control, cargo handling and loading, packaging and air terminal design. Douglas is well qualified for this program by its more than 20 years in all phases of cargo transport. Air logistics is only one area of extensive Douglas operations in aircraft, missile and space fields in which outstanding openings exist for qualified scientists and engineers. Some are listed on the facing page.

Schuyler Kleinhans and Charles Glasgow, Chief Engineers of the Santa Monica and Long Beach Divisions, go over air transport needs relating to advanced cargo loading techniques with Donald W. Douglas, Jr., President of DOUGLAS

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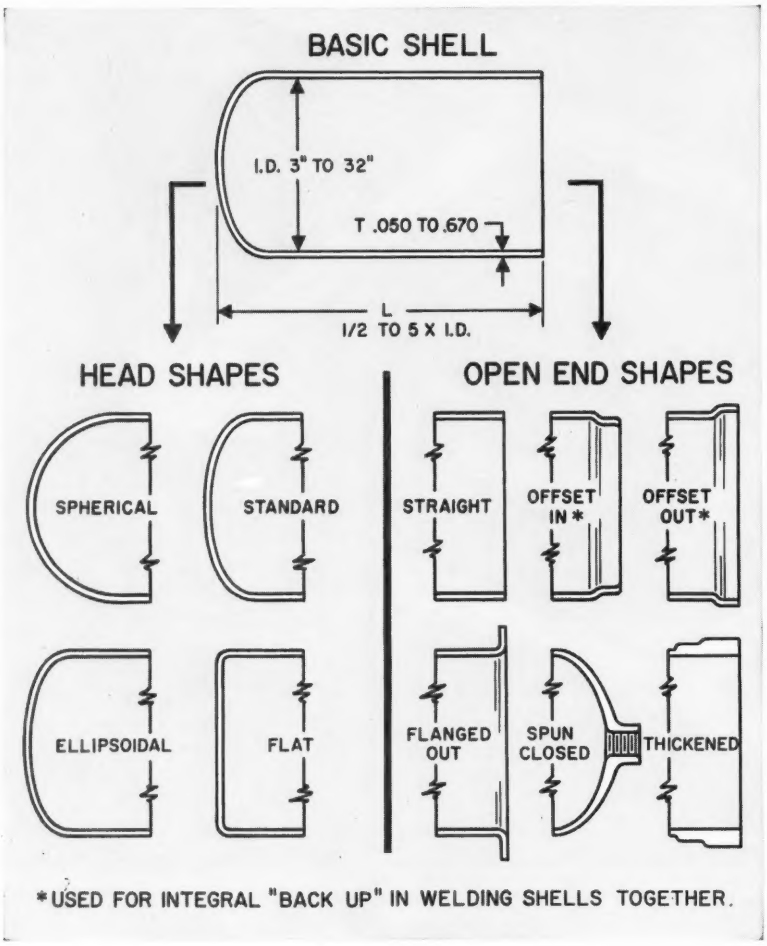

The drawings shown here give you a simple description of the way you can use basic Hackney shells to produce a variety of seamless, lightweight, strong, low-cost rocket motor cases, gas generator housings, control actuator pressure vessels and other missile components.

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Instrumentation

(CONTINUED FROM PAGE 36)

be of the order of 5 parts in 10^{10} or about 50 microsec per day. Allowing for transmission-time uncertainties of about 5 microsec, a clock with a precision of 1 part in 10^{11} over a period of several weeks appears to be required.

The Bureau of Standards has proposed to meet this requirement with a gas maser in a package weighing about 50 lb for 20 days of operation. The principle employed involves the detection of a hyperfine transition in the microwave absorption spectrum of Ru^{87} vapor at 6834.68 Mc/sec. The light pump involves a Ru lamp, a Ru^{85} vapor filter, and a Ru^{87} absorption cell. The last is placed in a microwave cavity, and the transmitted light beam is measured by a solar cell.

The remainder of the apparatus includes a transistorized quartz-oscillator frequency source and multiplication chain, the output of which drives a crystal harmonic generator to give the desired 6834.68-Mc/sec power. Phase modulation of the applied frequency and synchronous detection would be used to provide a correction voltage to the oscillator, whose frequency could then be fed to a scaler to produce timing pulses for transmission. The power requirements and weight of the frequency source, servo system, scaler, and transmitter are estimated at 3 watts and 20 lb. Adding battery weight for 20 days of operation brings the total weight to about 50 lb.

Measuring Magnetic Fields

Great interest attaches to the measurement of weak magnetic fields in space since interplanetary magnetic fields can profoundly affect earth-sun phenomena. Knowledge of the magnetic field of the moon would contribute to our understanding of its formation as an earth satellite. The specification on a magnetometer for a deep-space probe is a sensitivity of 10^{-7} gauss, an accuracy of one part in 10^5, and freedom from drifts due to thermal and mechanical shocks, besides the usual weight and power restrictions and elimination of magnetic materials. For example, the magnetic material in a transistor shell at a distance of 1 ft may produce a stronger field than that to be measured. It appears that the use of the optical-pumping principle in rubidium vapor can provide a magnetometer of the desired accuracy. Varian Associates is developing such an instrument under contract to NASA.

Leading the way toward the instrumentation of astronomical space observatories is Project Stratoscope. On

July 11, a polyethylene Skyhook balloon carried a 12-in. telescope, a 35-mm motion picture camera, and a television camera to a height of 81,000 ft over Minnesota. While floating at that altitude for several hours, the Stratoscope photographed thousands of pictures of sun-spot areas resolving details as small as 100 miles in diameter. The TV images transmitted to the ground permitted remote-control focusing and selection of the fields of view.

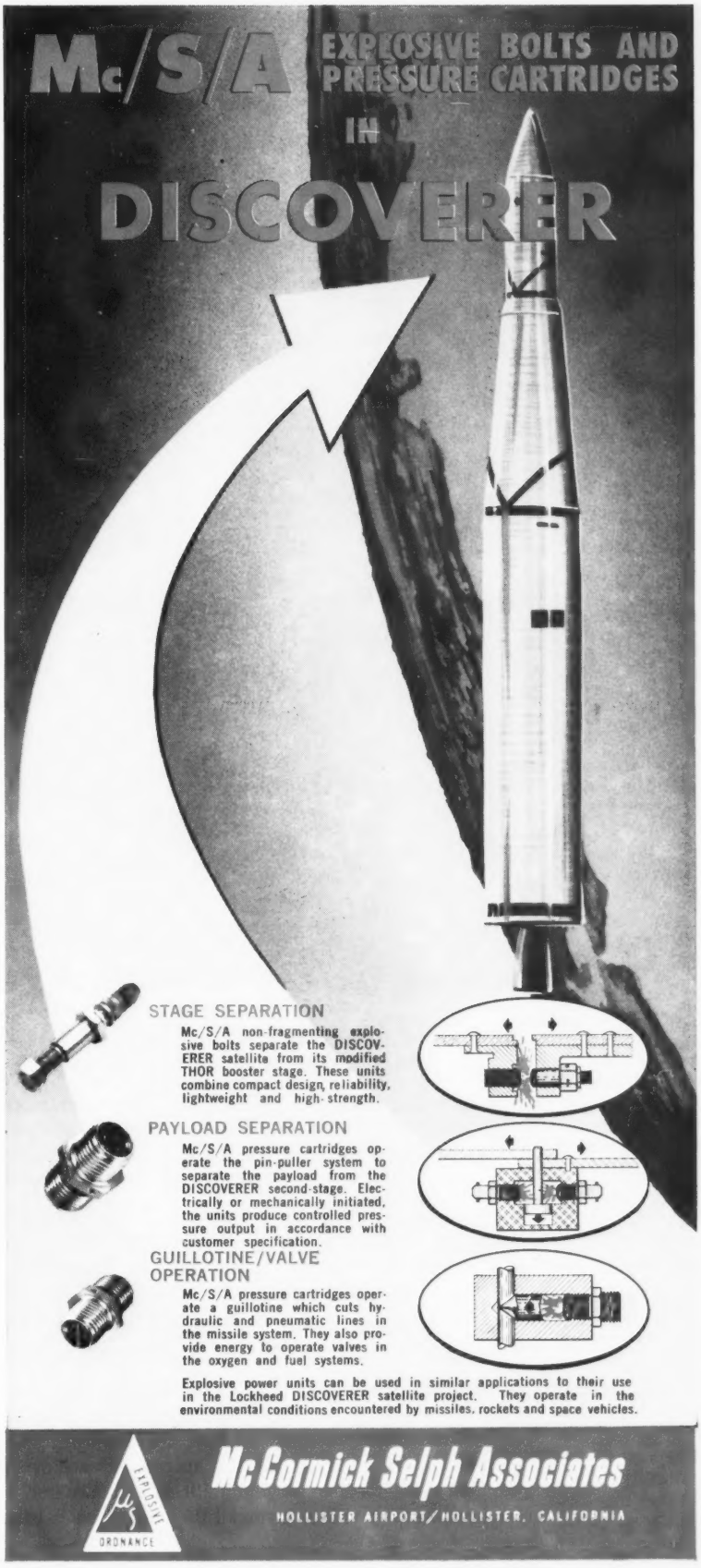
Telescope Performance

By getting above the tropopause, where turbulence causes twinkling, it is estimated that a 50-in. telescope could outperform the 200-in. telescope on Mt. Palomar. At satellite altitudes such a telescope would also provide a view of the universe in the wide range of ultraviolet wavelengths that are completely absorbed by the atmosphere. The problem of instrumenting such an observatory in space all but staggers the imagination, yet a serious program has been initiated to carry it out under the direction of A. Meinel of AURA, with support from the NSF.

Consider some of the problems to be faced in such a project. During the flight into orbit, the telescope optics must survive launching accelerations of 25 g (linear), plus noise accelerations of 20 g over a frequency range of 10 to 1000 cps and still arrive in orbit without loss of collimation. Residual angular momenta after launching must be zeroed to as high an order of accuracy as the required pointing accuracy. Gyroscopes can not be used as a means of detecting residual angular momenta, because they would set up precessional forces if the telescope were slewed to a new star. Instead of gyros, star monitoring would provide the means of detecting residual angular momenta. Pointing a telescope in space could be accomplished by simply rotating a small mass, thereby causing the telescope to rotate in the opposite direction, according to the law of conservation of angular momentum. Some disturbances will be introduced in the form of librations due to the figure of the earth if the satellite has unequal moments of inertia about its axes.

Yet, in spite of these problems, it is believed that guiding the orbital telescope should be easier than directing a terrestrial telescope.

Apart from launching problems, there will be difficulties introduced by thermal strains, since the telescope will be exposed to full sunlight on one side and dark, cold space on the other. Thermal radiation can decollimate the optical system and warp the mirror. Components must therefore be selected to minimize the effects—for ex-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Mc/S/A pressure cartridges operate a guillotine which cuts hydraulic and pneumatic lines in the missile system. They also provide energy to operate valves in the oxygen and fuel systems.
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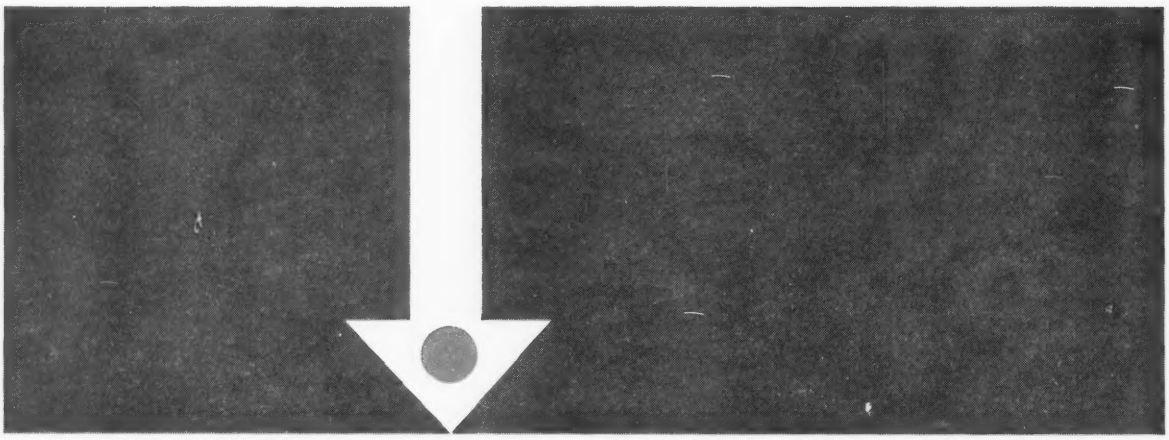

At IBM, scientists, mathematicians and engineers are currently engaged in many unique assignments in advanced physics. For example:

1. Photoelasticity is being studied to determine strain propagation as a function of time in solids. This work is designed to clarify laws governing impulse strain waves, as well as to determine dynamic stresses that exist in impact and other phenomena.
2. Fundamentals of the magnetic properties of materials are under study. The immediate interests are spin-wave investigations, particularly those relating to the switching times of remagnetization and spin-wave propagation in polycrystalline materials.
3. Optical techniques, with organic and inorganic thin films, are being used to examine the properties of absorption phenomena in surfaces and substrates.

You'll find a wide range and diversity of career areas at IBM. Advancement is rapid, due in part to the demands of a constantly expanding program of research and development, and in part to a long-continued record of promoting from within, based on individual merit and achievement. Depending on your field of interest and on your abilities, you may work alone or as a member of a small team. You'll be given all the specialized assistance you need.

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Determining dynamic behavior of micromagnetic fields by applying low-level, high-frequency circuit knowledge for small, closely coupled circuits as a result of Hall effect studies.

Study of basic scientific phenomena in the field of energy conversion; design of experiments for the investigation of electrical discharge in various environments and investigation of distribution and loss of energy. The objective is to develop energy conversion techniques that exceed the limited performance and efficiency of existing conversion methods.

Physical-mathematical studies to determine how complex control problems may be solved with digital computers. Applications in missile systems and special-purpose computer systems.

Development of magnetic devices for use in logic switching and computer "memory." Experience in fundamentals of nonlinear magnetics necessary.

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ample, thin-walled invar tubes for the collimator structure, fused quartz or Pyroceram for the mirror. Consideration is even being given to a beryllium mirror, which would have a high thermal conductivity and low mass.

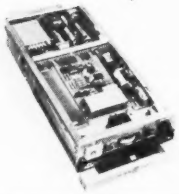
The reflectivities of common mirror surfaces become very poor in the ultraviolet, and only within the past year has encouraging progress been made. Tousey at NRL and Hass at Ft. Belvoir have succeeded in producing 90 per cent reflectivity at Lyman-α with a combination of a thin film of magnesium fluoride deposited over a surface of aluminum. The tremendous improvement in optical speed afforded by this development made possible the remarkable rocket photographs of the sun in Lyman-α achieved by the NRL last March. The reflectivity problem becomes more difficult at still shorter wavelengths, and it remains to be seen if substantial improvements can be made at wavelengths below 1000 Å.

Ultraviolet Detection

Of the many developments in ultraviolet detection, space doesn't permit the mention of more than one or two. A remarkable new electron multiplier has been developed by the Bendix Research Laboratories for the measurement of extreme ultraviolet radiation and has been applied successfully to rocket spectroscopy by H. Hinteregger of AFCRC. The multiplier surfaces are two parallel conductive strips of tin oxide film deposited on glass plates separated by a small gap. Voltage is applied across the lengths of the conductive strips to produce an accelerating field directed diagonally across the gap between the plates. A transverse magnetic field causes the electrons to describe cycloidal paths down the length of the gap with gains of the order of 100/cm of path. Of special value in rocket spectroscopy is the extreme insensitivity of these multiplier surfaces to wavelengths longer than Lyman-α (1216 Å).

Lallemond in France has produced electron multiplier tubes of very high gain and low noise. His tubes have 20 dynode stages operating at 100 volts per stage. It is easy to see the statistical noise in a beam of as few as 100 photoelectrons per second without resorting to cooling.

Microminiaturization of electronic circuitry has continued to develop rapidly. At the current stage of development, reliability still lags behind conventional circuitry and production techniques are experimental and complex; but the accomplishments in prototype developments are impressive, and the yield of practical applications of research in solid-state physics is



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rapidly growing. The fields of major activity include solid-state memory storage and logic devices. These involve the use of thin films, multiaperture magnetics, twistors, optoelectrics, and cryoelectrics. Equally important are solid-state contributions to parametric amplifiers, masers, and parametrons. In the category of computer memory devices, much research is devoted to magnetic drums, ferrite matrices, ferroelectric matrices, barrier-grid cathode ray tubes, and mercury and magnetorestriction delay lines. Operational requirements call for order-of-magnitude increases in the speed, and corresponding decreases in the size, of temporary memory units.

A few examples may serve to illustrate the trend of developments in this area. A magnetic ferrite in the form of a toroid is capable of storing a binary digit, and ferrite cores may be combined in matrices to provide memory units. By drilling a ferrite plate with holes and printing the circuitry, a miniaturized unit can be built with a memory of several tens of thousands of digits and an access time of 50 microsec, this speed being limited by current requirements.

Also, ferroelectric memory devices made of barium titanate can be built to sizes of 20 x 20 elements with response times of a microsecond. Superconductive devices such as the cryotron and evaporated magnetic films appear promising. The cryotron uses the destruction of superconductivity in tantalum wire by the magnetic field of a coaxial superconducting solenoid. The tantalum wire acts as a gate, two cryotrons forming a bi-stable flip-flop, with a maximum rate of 10 kc/sec. Inherently limiting the speed are eddy-current effects, which can be reduced by substituting evaporated films for wires. For example, a thin-film cryotron may use evaporated tin for the gate and a strip of lead film for the solenoid control perpendicular to the gate, with a thin layer of insulation between. Switching times of about 1 microsec are obtainable. The successful development of such thin-film devices is essentially a problem in the technique of deposition of thin films with prescribed purity and structure.

What of test and control instrumentation? Broadly speaking, the problem of engineering rocket propulsion systems is one of harnessing the tremendous energy of powerful engines. As the energy requirements become greater, phenomena such as combustion instability, detonation, power excursion, etc., create major problems in reliability. Other contributing factors are related to high temperatures, cryogenics, radiant heat transfer, and the containment of very high pressure. In all of these problem areas, advanced instrumentation is an important key to progress.

The demand for transducers to measure vibration, stress, strain, acceleration, and temperatures has led to marked improvements in frequency response, miniaturization, and signal output. Phenomena in the millisecond region are easily studied. Now research in the microsecond and submicrosecond regions has been made possible. Newly developed techniques will promote progress in understanding the fundamental dynamic and transient phenomena related to operation of a propulsion system, such as thrust generation and termination, the formation of shock waves, and impact phenomena.

Data-acquisition and computational developments have made great strides during the last few years, so that hundreds of channels of information can be gathered, multiplexed, and converted from analog to digital form at the rate of 10,000 to 50,000 conversions per channel on a routine basis. With advanced techniques, such conversions can be made at rates expressed in terms of tens of conversions per microsecond, thereby greatly multiplying our ability to deal with complex information.

Advanced Instrumentation

The following are a few examples of advanced instrumentation that have been noted by members of the Instrumentation and Controls Committee. Measurements of high-frequency physical phenomena during rocket-engine static-firings are usually recorded in analog form on magnetic tape. DIDA (Dynamic Instrumentation Digital Analyzer) is a system designed to convert selected portions of analog tape-recorded data to a digital format on magnetic tape acceptable to a large digital computer. The effective sampling rate of DIDA is 100,000/sec, which is satisfactory for a digital representation of information frequencies from 0 to 10,000 cps. Amplitude and time accuracies of the DIDA system are at least an order of magnitude better than the accuracies of the original analog data. The DIDA system makes the powerful analysis capabilities of machines such as the IBM 709 available to any analog information recorded on magnetic tape.

Statistical techniques have been applied to monitoring the precision of measuring systems. The determination of performance reliability of propulsion systems is significantly related to the capability of the measuring system used in generating the data. For this reason, it is desirable to isolate

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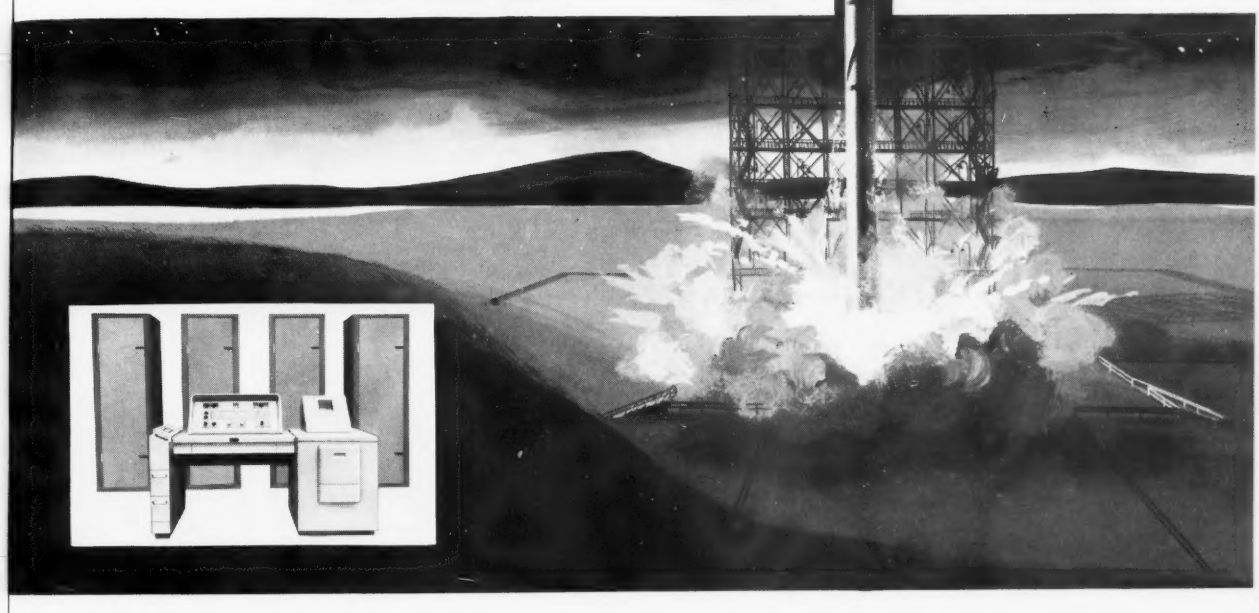

APCHE (Automatic Programmed Checkout Equipment) is a solid-state, universal, high-speed, highly reliable, compact general-purpose tester designed especially for automatic checkout of aircraft, missile and space systems and their supporting systems. In its various versions (differing in input media, size and weight) APCHE installations may be fixed, mobile, airborne or submarineborne. APCHE was designed and is being produced as a part of RCA's ground support electronics subcontract from the Convair (Astronautics) Division of General Dynamics Corporation, prime contractor for the ATLAS Intercontinental Ballistic Missile.

The system being supplied to Convair for the ATLAS Program includes a console and four rack cabinets providing both analog and discrete test functions with a resulting printed and GO-NO GO indication. As a product of RCA's Missile Electronics and Controls Department, Burlington, Massachusetts, APCHE is one of the latest RCA developments in the field of military weapon readiness equipments.

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the performance of the measuring system from that of the composite performance indicated by engine data records. To perform this function, a program employing statistical techniques has been applied to monitor continuously the precision of measuring systems. The statistical techniques include the determination of standard deviation and the use of confidence factors and tolerance limits in the prediction of performance over periodic intervals. These techniques are applied through the use of IBM computer programs, and result in dissemination of periodic information on a scheduled basis. The program provides uniformity in the evaluation and use of measured data. The net result is an improvement of both the measurement system and component performance and optimization of calibration procedures.

In the field of thermometry as applied to cryogenic liquids, the development of high-resistance platinum elements with time constants of the order of 0.1 sec now permits temperature measurement of cryogenic liquids to a higher degree of precision and accuracy than possible before with no sacrifice in response. Durability in the rocket-engine environment has been good, setup and calibration are simple, and the precision is better than 0.5 F.

The precision of volumetric flow metering devices has been considerably improved. Facilities for the calibration of turbine flow meters now exist for use with ambient as well as cryogenic liquids which yield precisions of 0.05 per cent.

In summary, it can be said that advances in instruments have made it possible for both the researcher in basic science and the design engineer to obtain more data more rapidly and to extend the scope of his experimentation by virtue of increased sensitivity and reliability. This brief summary of the state of the art in instrumentation has been prepared with the assistance of my committee colleagues, Frederick F. Lui, Edward Cartotto, John E. Witherspoon, and George W. Hoover.

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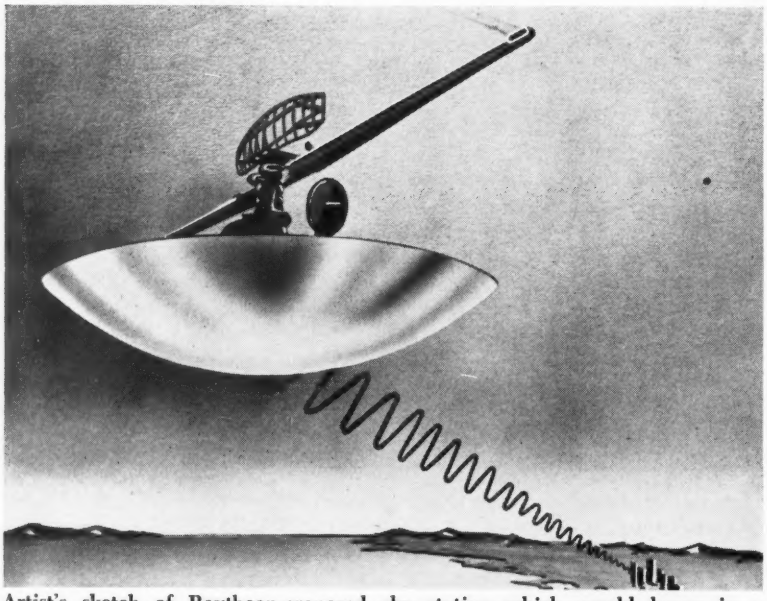
Station in the Sky



Artist's sketch of Raytheon-proposed sky station which would hover in a fixed position above the earth by using microwaves beamed from the ground.

Transmission of substantial amounts of power through beamed microwaves may make practical an equipment-loaded platform which can hover indefinitely miles above the earth.

The Raytheon Co. believes that a battery of its high-frequency, high-power Amplitron tubes, driving a 400-ft-sq array of antennas, can deliver enough energy to a 100-ft-diam area in the sky to power a sizable helicopter-like rotor on the station with hot-air turbines. Microwave energy, delivered in such a manner, would be picked up by a circular array of antennas on the station and converted to heat there by waveguides and "lossy" electronic elements. Compressed air heated by the lossy elements would run the turbines.

About 35 per cent of the ground power, it is expected, would be delivered to the heat-exchange system. The station would operate automatically. An auxiliary chemical powerplant would supply energy to raise the station into position, descend it, and give emergency power.

As envisioned by Raytheon, hovering sky stations would have such uses as relay points for intercontinental telephone and television, early warning radar posts, and atmosphere research platforms. The AF is studying applications and technology of the sky platform idea with Raytheon.

COMPLETING THE PICTURE . . .

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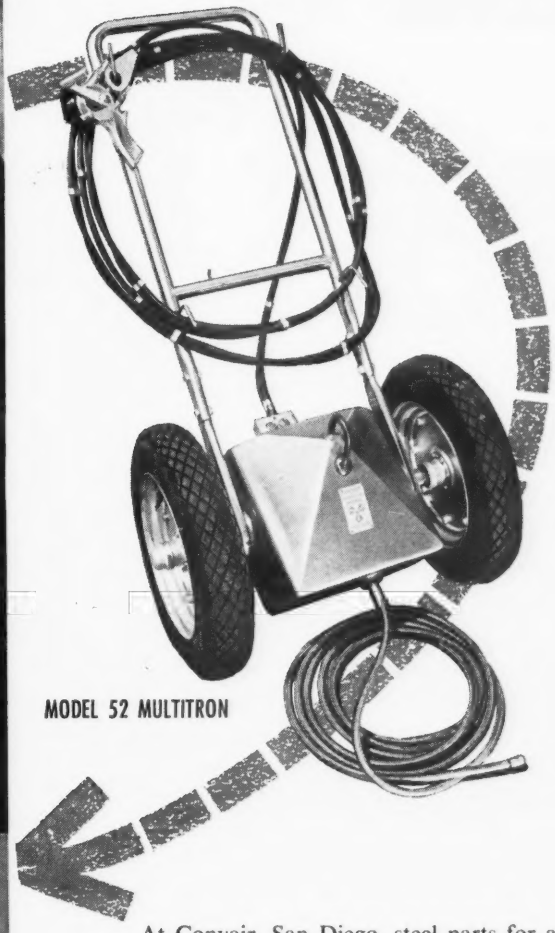
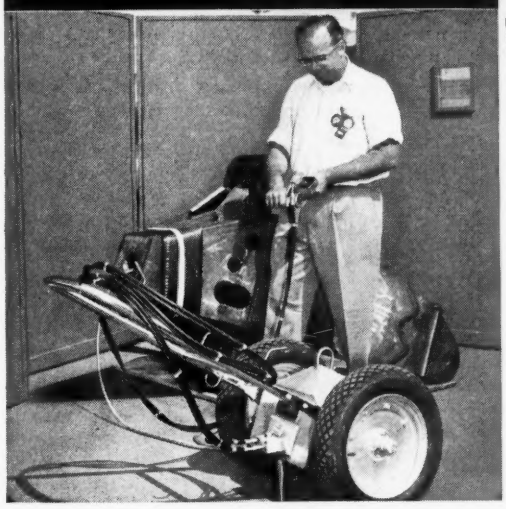


MODEL 52 MULTITRON



At Convair, San Diego, steel parts for air or space craft must be absolutely flawless to take their designed loads. Quick, positive inspections of these parts are made by a Nuclear Systems Model 52 Multitron with a cobalt 60 source. The unit can be wheeled about at will . . . wherever radiographic inspection is needed.

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People in the news

APPOINTMENTS

Walter C. Williams, former chief of NASA's high-speed flight station at Edwards AFB, Calif., has been named an associate director of Project Mercury. **Paul F. Bikle,** former technical director of the USAF Flight Test Center at Edwards, succeeds Williams. In other NASA appointments, **Arnold W. Frutkin,** former director of the office of information, USNC-IGY, has been named director of the Office of International Programs, and **Robert W. Kamm** has been appointed director of the western operations office at Santa Monica, Calif.

Princeton Univ. has announced the promotion of **Irvin Glassman** to the rank of associate professor of aeronautical engineering. Dr. Glassman has been with the *ARS Journal* since 1951 and is now an Associate Editor.

Otto Struve, former professor of astronomy and director of the Leuschner Observatory, Univ. of California, has been appointed the first director of the National Radio Astronomy Observatory, Green Bank, W. Va.

Robert M. Witucki, former assistant manager of the Advanced Materials Dept., Curtiss-Wright Corp., has joined Hoffman Electronics Corp.'s new science center in Santa Barbara, Calif., as a senior scientist.

Everett T. Welmers, director of plans and programs for Bell Aircraft Corp.'s Niagara Frontier Div., has been granted a one-year leave of absence to join ARPA, where he will work in the areas of ballistic missile defense and space technology.

Chief engineer **T. F. Dixon** has been named director of engineering for Rocketdyne in a major expansion of the technical organization following integration into Rocketdyne of the solid propulsion activities of the former Astrodyne, Inc. The expansion also saw the appointment of **P. R. Vogt,** former assistant chief engineer, to chief engineer, liquid prepellant engines, and of **J. F. Tormey** to chief engineer, solid propulsion. Dixon will continue to have direct line responsibility for all research and liquid rocket engineering, and will also be responsible for developing engineering policies and objectives in the solid rocket field. Fundamental research on solid propellants and solid rockets will be conducted at Canoga Park, Calif., along with R&D work in other areas of rocket propulsion.

George Gerard has been appointed associate director of the Research Div. of New York Univ. Dr. Gerard, chairman of the ARS Structures and Materials Committee, was formerly assistant director of the division.

Capt. Norman Lee Barr, former director of aviation and space medicine research for the U.S. Navy, has retired from active duty and joined Republic Aviation Corp. as chief of space environment and life sciences research. **S. Michael Treman,** formerly head of Treman Electronics & Mfg. Corp., has joined Republic's Missile Systems Div., where he will be responsible for technical design efforts.

A. T. Forrester has joined Electro-Optical Systems as head of the Ion Propulsion Lab, Fluid Physics Div., while **Frank Manov** has been named supervisor of the company's newly formed satellite and space defense studies group.

Frederick D. Dodge has been named chief engineer of Minneapolis-Honeywell's Missile Equipment Div., and **John G. Erickson** has been promoted to supervisor of synthesis research, ARPA solid-propellant project, at M-H's Central Research Dept.

George W. Weiler has been promoted to chief electronics engineer responsible for design of all Talos missile electronics systems at Bendix Missiles Div.

Armour Research Foundation has named **Morton J. Klein** supervisor of propellant chemistry.

John N. Monroe, former president of Monroe Laboratories, has joined Firestone's Guided Missiles Div.

Thomas L. Regan has been named general manufacturing superintendent for North American's Missile Div.

Aerojet-General has named **Gordon Banerian,** vice-president—engineering; **Gordon C. George,** manager, office of program planning; and **A. Stanley Thompson** to a staff position at its wholly-owned subsidiary, Aerojet-General Nucleonics. **L. M. Limbach** has been appointed corporate director of manufacturing for the parent company.

Alfred P. Higgins has been named manager of the new Base Activation Dept. of Convair-Astronautics, organized to facilitate activation of Atlas bases.

P. K. Reilly Jr. has been named head of the Atlantic Research Corp. Development Dept. succeeding **DeWitt O. Myatt,** who has resigned to form his own consulting firm, Science Communication, Inc.

G. R. Makepeace has joined Grand Central Rocket Co. as vice-president for research engineering, with **J. Edmund Fitzgerald** named technical specialist for engineering and **T. F. DeBauw** appointed to the post of assistant project manager, Zeus project.

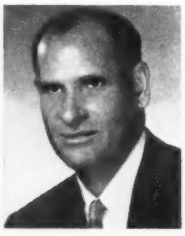
Richard W. Harbison has joined Lear, Inc., as assistant to the executive vice-president.

Col. Bernt Balchen has joined General Precision Laboratory as an aviation consultant.

Charles B. Wilson has joined Fairchild Astrionics Div. as systems engineer for the Army Signal Corps SD-5 battlefield surveillance system.

William L. Whitson has been named

Glassman


Dixon

Gerard

Treman

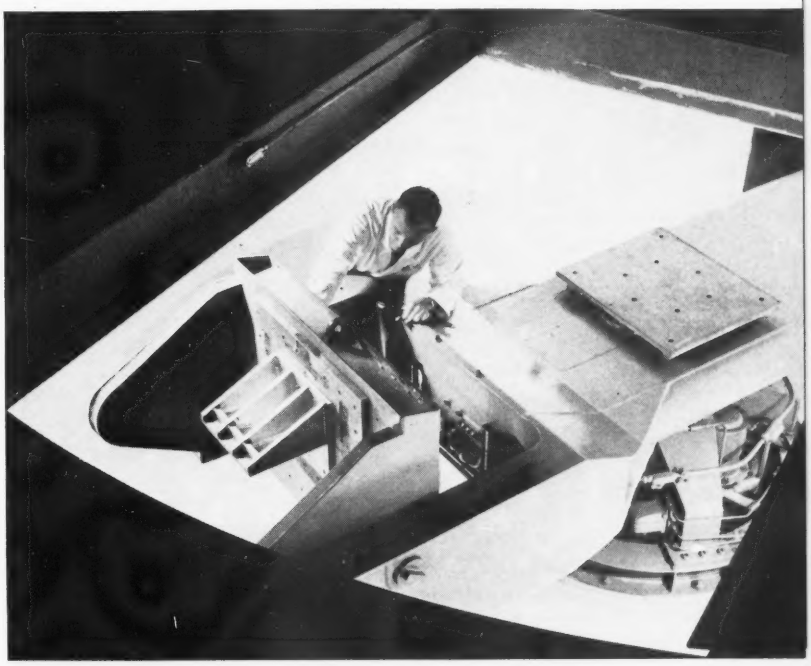
Dodge

Weiler

(left) Navy POLARIS AX-1 flight test vehicle at beginning of launch. Lockheed's POLARIS fleet ballistic missile is more than a year ahead of original schedule.

(below left) One of the Santa Cruz test stands with dynamic thrust mount to simulate flight environment. Vibration oscillator functions during static firings.

(below right) Large centrifuge for environmental testing has unique shaker attachment to provide vibration simultaneously with high G-loadings.



TEST / Expanding the Frontiers of Space Technology

Testing is a vital part of every stage in the development of missile and space programs at Lockheed Missiles and Space Division.

The Division maintains one of the most completely equipped missile and space test laboratories in the world. Equipment includes: altitude, temperature and humidity chambers; shaker and vibration systems; G-accelerators; and apparatus capable of performing chemical, metallurgical, plastic, heat transfer, hydraulic, pneumatic, shock, acceleration, sinusoidal and random vibration, structural, electrical, and electronic tests. Static field testing; research and development testing on controls; testing in ordnance and hydraulics and high-pressure gas and propulsion systems are conducted at the 4,000 acre, company-owned test base in the Ben Lomond mountains near Santa Cruz, California.

Flight testing is conducted at Cape Canaveral, Florida; Alamogordo, New Mexico; and Vandenberg AFB near Santa Maria, California; in a unique manner. All components and sub-systems of a new project are initially tested on known-performance, production missiles. Thus, when the final system is ready for first flight, its individual components already have flight-tested reliability. This new concept of flight testing has enabled Lockheed to produce extremely complex missile systems in record time and at greatly reduced expense.

Underwater launch tests—including studies of cavitation, wave simulation and skip motion—are carried on at the Sunnyvale facility and at the Navy test base on San Clemente Island. In addition, structural and other tests are performed at Hunter's Point Naval Shipyard, California.

If you are experienced in any of the various phases of testing, we invite your inquiry. Positions also are available in physics, mathematics, chemistry, or one of the engineering sciences. Write: Research and Development Staff, Dept. K-14, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship required.

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CAPE CANAVERAL, FLORIDA • ALAMOGORDO, NEW MEXICO • HAWAII

Whitson

Klemach

Turner

Teeter

Krafve

Oldfield

a vice-president of Daystrom, Inc. He was formerly deputy chief scientist of ARPA.

Fred A. Klemach has been promoted to missile systems manager for Vickers, Inc. Past president and director of the ARS Detroit Section, he was previously senior staff engineer specializing in missile applications.

Robert S. Turner has been named head of flight testing at Martin-Baltimore, succeeding **George A. Rodney,** who becomes manager of the Test Complex at Martin-Denver. **G. Howard Teeter** has been appointed assistant general manager of Martin-Denver, in charge of a newly formed Electronics Div., while **Hugh L. Cox** has been appointed lead engineer on advanced classified projects.

Richard E. Krafve has been elected executive vice-president and **Homer R. Oldfield** has been named vice-president, electronic components and devices, at Raytheon.

John W. Christensen and **Robert A. Gregg** have been elected vice-presidents of Space Recovery Systems, Inc.

Lt. Col. Nils M. Bengtson has been named director of the Army Guided Missile Agency's Ordnance Missile Labs Div., succeeding Col. Thomas E. Wood, who has retired.

Frank P. DeLuca Jr. has been appointed executive vice-president of Acoustica Associates.

Ryan Aeronautical Co. has named **John W. Rane Jr.** director of military relations.

Amcel Propulsion, Inc., an affiliate of Celanese Corp. of America, has named **Julius P. Zeigler** vice-president and general manager. He was previously manager of high-energy materials operations for Celanese.

John K. Records has been appointed manager of the newly formed Military Systems Section of GE's Defense Systems Dept.

Siegler Corp. has integrated all its defense activities under **John J. Burke,** elected vice-president, who will coordinate the military activities of four Siegler divisions.

V. P. Kovacik has been named research requirements manager and **M. J. Corbett** development requirements manager for the Tapco Group, Thompson Ramo Wooldridge.

Richard S. Weiss, vice-president of Avica Corp., has been named chief technical engineer, responsible for development of advanced components for the aircraft and missile industries.

Phelps Trix has been named director of product development and **Kurt C. Frisch** director of polymer research, heading two new departments formed by Wyandotte Chemicals Corp.'s Research Div.

Raymond A. Runyan, one of the founders of Data-Control Systems, has been elected vice-president of research and development.

Raymond C. Blaylock, vice-president, Chance Vought Aircraft, has been named director for the newly formed Astronautics Div. **J. R. Clark,** former director of engineering, will serve as general manager; **A. L. Jarrett** as engineering manager; **G. B. Shaw** as manufacturing manager; and **M. R. Seldon** as quality assurance manager. Blaylock will also supervise the newly formed Range Systems Div., with **S. O. Perry** as manager. **H. B. Gibbons** becomes associate director of the Research Div.

Joseph F. Hill, former chief engineer of products design and engineering, Janitrol Aircraft Div. of Surface Combustion Corp., has been named manager of engineering for the division.

Rabindra N. Ghose will head Space Electronics Corp.'s newly formed Exploratory Development Dept.

William B. Bergen, formerly executive vice-president of Martin Co., has been elected president.

HONORS

John W. Crowley Jr., former director of aeronautical and space research for NASA, has been awarded the NASA Distinguished Service Medal for "outstanding leadership in aeronautical science," at a dinner marking Crowley's retirement from government service after 38 years as a research scientist for NACA.

Maj. Gen. Ben I. Funk, commander of the AMC Ballistic Missiles Center, Inglewood, Calif., has been selected as winner of the AF Assn. Distinguished Management Award for making the most distinguished contribution to management in a position of great responsibility.

Charles C. Hill, consulting engineer for Vector Corp., Birmingham, Mich., has won the annual award from *Materials in Design Engineering* for the best use of materials in product design. Hill designed a new gas turbine inlet section which provides maximum silencing effect.

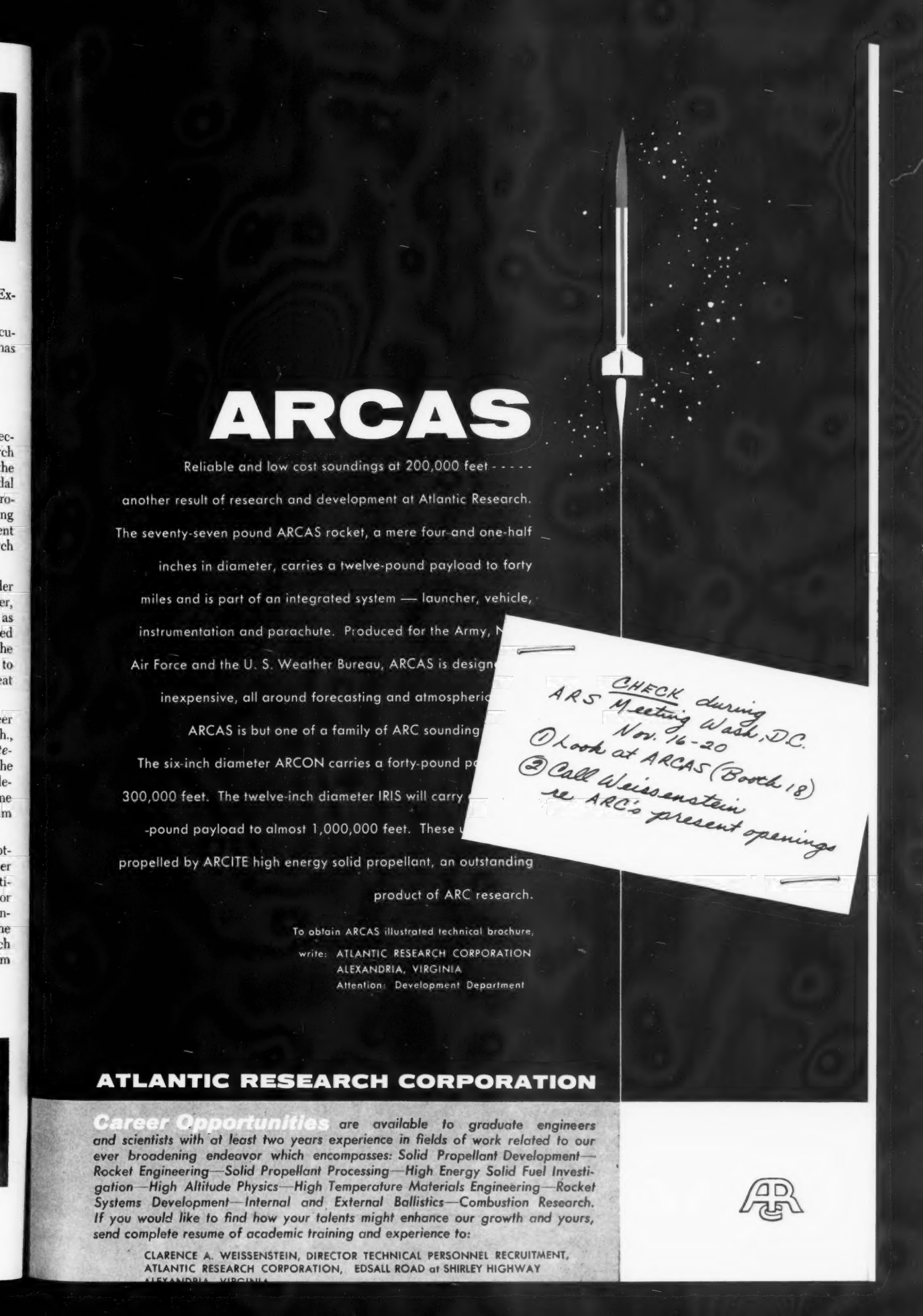
David M. Potter, president of Potter Aeronautical Corp., and Potter Pacific, will receive the Franklin Institute Edward Longstreth Medal for his design of the Pottermeter, an instrument used to determine the amount of liquid flowing from such things as the fuel tank of a jet or from bulk storage tanks.

Zeigler

Burke

Blaylock

Clark



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Positions are open in Honeywell's Aeronautical Division for three qualified senior engineering specialists. Duties are 1) to guide development and design projects in the application of advanced techniques to Honeywell designs; and 2) provide technical assistance in specialty areas for selection and execution of new system and new product developments.

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RADAR AND RELATED SYSTEMS

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ELECTRONIC CIRCUITS

First-hand knowledge of design techniques for advanced circuits—dc, low frequency, pulse, and r.f.—for control, computation, measurement, and communication. Must be knowledgeable with respect to solid state devices and circuits and interested in making major contribution to Division application of microcircuit techniques.

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J. R. Rogers, Chief Engineer,
Preliminary Development Staff, Dept. 68A

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NASA Program for 1960

(CONTINUED FROM PAGE 25)

velopment phase.

The NASA spaceflight program for the next year, aside from Project Mercury, is directed partly toward the space sciences and partly toward the satellite meteorological and communications systems which should be of great value to the civilian economy. For this period, the principal launching vehicles are expected to be the Juno II and Thor-Delta, an improved version of the Thor-Able. However, initial development flights of the Scout, a relatively small, solid-propellant vehicle having about the same capabilities as the Juno II or Thor-Delta, should also be underway. It is expected that the Scout, after development, will provide a relatively simple and inexpensive vehicle for the simpler missions.

In addition to these space vehicles, a considerable number of sounding rockets will be used, some for scientific measurements in the upper atmosphere and some for engineering research purposes. Typical of these is a six-stage rocket launched from the Wallops Island test range for high Mach number atmospheric heating tests.

During the year, the space sciences program will continue the investigation of the Great Radiation Belts surrounding the earth, should expand our knowledge of infrared radiation from the earth and of the solar ultraviolet and higher frequency radiations, measure the earth's magnetic field, and improve our knowledge of the composition and structure of the outer reaches of the earth's atmosphere.

While the earth's infrared radiations are of great interest to meteorologists, some experiments more directly aimed toward the problems of the weather forecaster are also planned. Orbiting flight of a large metalized plastic balloon is planned, partly as a passive reflector communications experiment, partly as a means of measuring the atmospheric density at extreme altitudes.

Another type of activity, less dramatic than flight-tests but of equal significance, is the research and analysis of new concepts which must be evaluated for the formation of future development projects. Typical of this type of work are the development of the one million-lb-thrust engine, nuclear-rocket research, and electric propulsion research. All of these efforts are directed toward potential propulsion systems for the manned spaceflight systems which will follow Project Mercury.

The previous remarks have been di-

rected toward those portions of the NASA program which are primarily concerned with the problems of spaceflight and the closely related problems of long-range guided missiles. Of equal importance are those portions of the NASA program directed toward the support of the nation's aeronautical activities, both military and civil. One of the areas of research is that of flight at hypersonic speeds. The X-15 research airplane project, a joint NASA-AF-Navy project, is one element of the over-all investigation.

X-15 Program Progressing

During the coming year, the X-15 flight-test program should start to contribute research information up to its design Mach number of six. In the lower supersonic speed range below Mach 3, the problems are more clearly defined and sufficient information has been developed so that practical military aircraft have been developed. On the other hand, our most advanced civil aircraft are still subsonic.

Another group of investigations is directed toward refining the understanding of problems of this lower supersonic speed range, and should contribute to the determination of the practicality of supersonic transport aircraft. Still another group of investigations is directed toward the lower limit of flight speeds and the problems of VTOL and STOL aircraft.

There, then, are the highlights of the NASA program for the next year. Translating this plan into action will require not only the efforts of the more than 11,000 persons either employed directly by NASA or employed under contract at the Jet Propulsion Laboratory, but also the efforts of many thousands of Department of Defense personnel for the many portions of the program which can be carried out most efficiently on a cooperative basis, and the efforts of many tens of thousands of people in industry.

Relying on the experience of the past, we can look forward to a year of hard work with not only some disappointments but also, on the whole, a good measure of satisfaction from accomplishments achieved and discoveries made. ◆◆

Booster Rockets For Private Aircraft

The Federal Aviation Agency has approved the use of optional booster solid rockets (Aerojet-General Model 15NS-250 motor) for the Beechcraft Twin-Bonanza executive aircraft.

Carl Baumgaertner, Assistant Chief Engineer, Ground Support Equipment, Honeywell Aeronautical Division

"Engineers . . . here are opportunities to work and grow in our ground support group"

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"If you are a qualified engineer interested in a rewarding career in this area of Honeywell Aero, send information on your background, interests, and accomplishments to Bruce D. Wood, Technical Director, Dept. 688".

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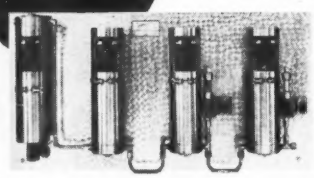

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From the patent office

By George F. McLaughlin

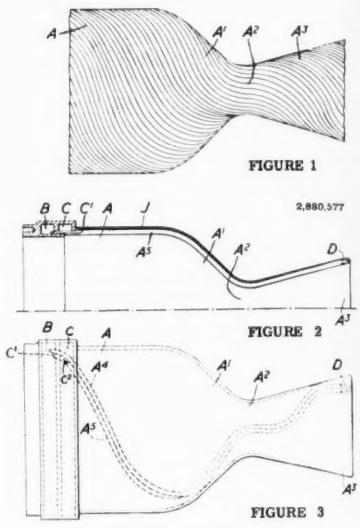
Compound-Curvature Regenerative Cooling

This invention advances compound-curvature channels for regenerative cooling. It specifies that the coolant, which may be propellant or some other liquid, should flow outside the rocket motor wall through tubes laid side by side and held together. The tubes have a complex but calculable curvature designed to cover the surface to be cooled. If circular tubes are used, they are bent to the required shape and nested together. Other than circular tubes are twisted in addition to being bent.

The diagrams at the right show a typical form of this cooling system. As shown in the top diagram, the chamber comprises a cylindrical part (A), a frusto conical part (A^1) leading to a throat (A^2), and a nozzle (A^3).

The tubes change angle of helix with the diameter of the chamber. Thus, over the cylindrical part the tubes have a constant small helix angle. This angle increases progressively as the tubes traverse the frusto conical part toward the throat. At the throat the tubes run parallel to the axis of the chamber. The helix angle again progressively decreases as the tubes pass from the throat along the nozzle section.

The middle and bottom diagrams show a single cooling channel in this system. One channel end (A^4) connects with a head chamber (B). The channel makes a circuit a common connecting cup (D) at the rim of the nozzle, and returns to another opening (C^2) of the head chamber. A pressure casing (J) encloses the whole system of channel tubes if pressures will be high. Otherwise, the tubes are simply joined by welding or brazing and the casing omitted.



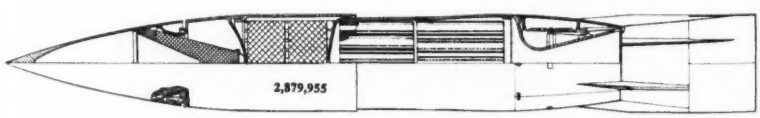
Typical form of cooling system.

Multi-Tubular Wall for Heat Exchangers (Patent No. 2,880,577). F. B. Halford, late of Northwood, England. Assigned to the DeHavilland Engine Co., Ltd.

Aerodynamic Control of a Rocket

This patent concerns the kind of control system seen in several solid-propellant anti-tank missiles. Very briefly, it employs a combination of aerodynamic surfaces, spoilers in the jet stream, and displacement of propellant mass during motor burning to give a rocket-propelled missile a flat and predictable trajectory. The figure below shows a drawing of an anti-tank missile according to the invention, the top part being in axial section and the lower part in elevation, with portions cut away. This is a patent that should be read in detail by missile design engineers.

Patent 2,879,955. Airborne bodies and, in particular, self-propelled missiles. Helmut P. G. A. R. von Zborowski, Brunoy, France.



Anti-tank missile following Patent 2,879,955.

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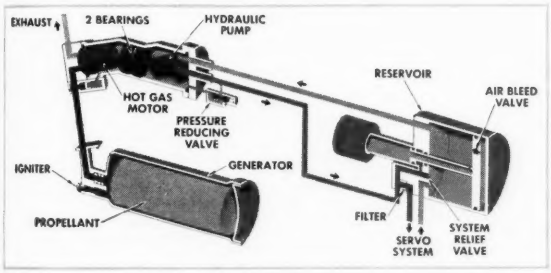
CONCEPT

Vickers piston motors — as used in virtually all existing commercial and military aircraft — are now modified to operate efficiently on propellant-generated hot gas, or bleed gas from the main propulsion system. Minimum weight is achieved by mounting the hot gas motor "shaft-to-shaft" with a Vickers piston hydraulic pump in a common housing. The motorpump, a simple gas generator, hydraulic reservoir, filter, and relief valve are integrally mounted to form a complete Auxiliary Power System in a compact package.



DEVELOPMENT

Production line Vickers hydraulic motors have been operating on hot gas for over 2 years. Units have run on gases as hot as 2300°F without modification.

The present flight hardware was built and tested after an intensive prototype development effort. Test program motorpumps have accumulated over 100 runs each for 1 minute of operation cycle. Since the current development program is aimed at meeting known APS requirements, no limits have been established on the operating cycle duration for this type of equipment.

CONCLUSIONS

Performance and reliability goals for this concept have been met successfully. A complete hot gas APS package in the 2 - 8 horsepower range, shown above, is available within 90 days. Customer specifications for these and larger systems are invited. Write for Bulletin A-5223B.

APPLICATIONS

Because of the increasing scope of APS applications, Vickers conducted a series of studies to establish criteria for APS selection. Recent study results (published in March, 1959) indicate that for short duration operation, hot gas motors offer the best weight advantage in the 1 to 30 hp range. See curve below.

Attractive reliability and early delivery resulting from extensive use of proven hardware may extend the application of these systems to an even greater range of second and third generation missiles and spacecraft. Additional advantages include: low speed equipment (up to 10,000 rpm), convenient ground checkout, growth potential, and no alert time required.

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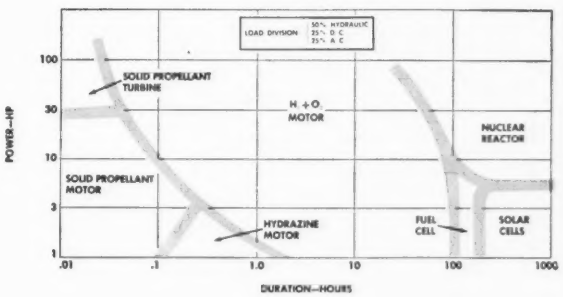

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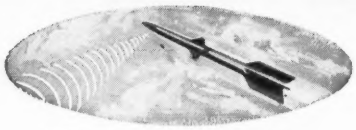

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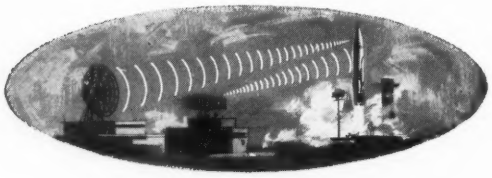

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Man's Mission in Space

(CONTINUED FROM PAGE 29)

The problem of the enclosed environment has been solved on a large-scale basis for the submarine. In an atomic-powered submarine, a large crew was successfully isolated for 60 days underseas. In X-series rocket-powered experimental aircraft, a completely self-contained environment similar to a space cabin for one astronaut was successfully used in numerous brief flights at hypersonic speeds and altitudes above 100,000 ft.

The closest approximation to the realities of one-man space exploration in a minimum environment was achieved in the Man High free balloon flight of 32 hr 10 min duration, where all the environmental factors of orbital flight except weightlessness were coped with. The subject of this experiment, Lt. Col. David G. Simons, was able to accumulate 5 hr of dictaphone recordings, 25 hr of intermittent radioed recordings, several rolls of motion picture films, packs of still color photos, and dozens of pages of written data, while continuously monitoring some part of 17 factors under his control for maintaining the prototype life-support system. These are encouraging indications of human ability to perform under stress comparable to that in spaceflights of similar duration.

With regard to factors in which spaceflight would go beyond the problems of survival in an isolated, self-contained, minimum life-support cabin, including the factors imposed by present propulsion systems, ample human reserves to endure the programed stresses, with a margin for survivable deviations, have been demonstrated in ground and flight simulation experiments. It is worthy of note that these factors have received careful evaluation during a decade prior to the design of a minimum survival capsule for actual spaceflight.

The human body, properly supported in a semirecumbent position, can endure continuous acceleration of 3 g from chest to back for 1 hr. As linear acceleration, this would attain nine times escape velocity, or over 232,000 mph. The human body in this same semirecumbent position can sustain 20 sec of a peak 16 g during a 4-min exposure to gradual increment and decay of acceleration simulating the most drastic re-entry configuration theoretically proposed. During 4-min continuous exposure to 8 g in this position, subjects were able to demonstrate adequate wrist and finger control to perform acceptable vertical and horizontal tracking experiments. In all anticipated three-stage rocket ac-

celeration programs proposed for either orbital or escape velocity flight, human subjects demonstrated ample tolerance during very complete investigations on the human centrifuges of the Navy and Air Force. Both the five-day exposure of the dog Laika in the Russian Sputnik II, and brief exposures of human subjects in the order of 15 to 60 sec by Keplerian trajectory, indicate no insurmountable problems from exposure to zero gravity. Definitive evaluation awaits the first human orbital flight.

According to James Van Allen, no serious radiation hazard should be encountered in orbital flights at altitudes of less than 600 km between north and south 40 deg latitude. For flights beyond the limits of the two Van Allen layers, escape through the polar clear areas can be accomplished through use of only a moderate amount of shielding. The somewhat Procrustean approach of confining one man to a minimum survival capsule limited in weight and volume by the specifications and performance of existing missiles for taking him into orbit, and exposing him to stressful accelerations in addition to known and unknown conditions of spaceflight that are beyond control, represent only the brave beginning.

Progress Is Inevitable

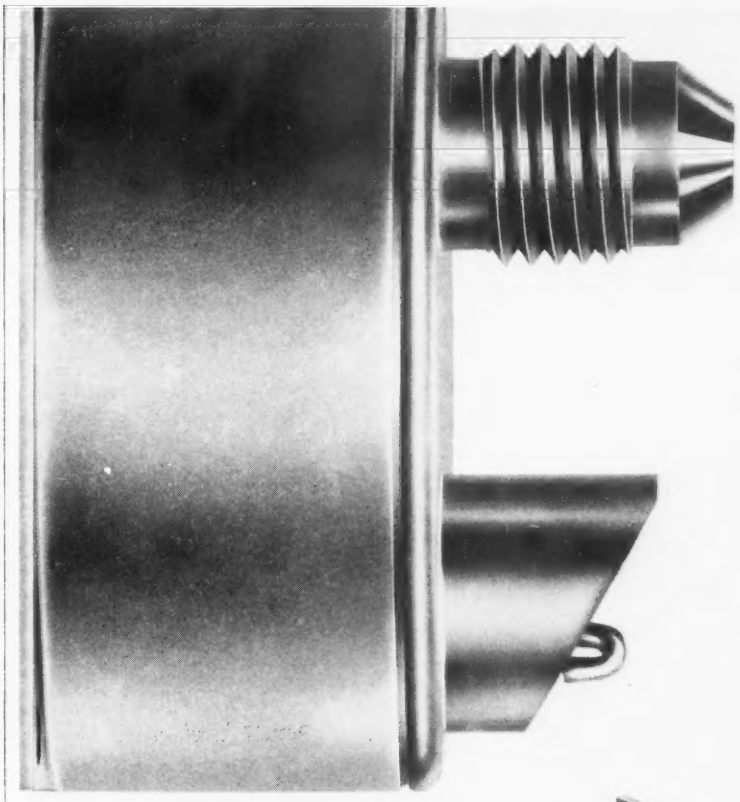
The successes and failures in the inevitable progress of this scientific mission will be no less stressful to those on the ground who dedicate themselves to the difficulties and responsibilities of the problems.

Today, Man rises to a self-made challenge greater than any ever faced by the human race. Here, Man aspires to lift himself beyond the safety of his terrestrial home and to override his own fears and limitations and explore the universe by spaceflight.

All the qualities of intelligence, perseverence, mutual cooperation, and courage that distinguish Man from other forms of life on our planet will find their supreme fulfillment in the successful accomplishment of this mission. ◆◆

NASA Western Office In Santa Monica Reorganized

NASA's Western Coordination Office at 150 Pico Blvd. in Santa Monica, Calif., has now been designated the Western Operations Office, and will henceforth provide administrative and management support for NASA west of Denver, Colo., as well as its previous liaison function.



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Education

(CONTINUED FROM PAGE 32)

manifest in several ways. First, recognized names in astronautical circles are besieged with requests for information and help in connection with hobbies, high school projects, planning of careers, etc., many of the type: "Please tell me all about rockets." Secondly, the tragic statistics of amateur rocketry experimentation recently documented by the ARS demonstrate misdirected motivation and a lack of real knowledge concerning hazards.[3-4] These problems are under consideration by several groups in the ARS.

ARS Sections Active

Singularly satisfying results in bringing astronautics education directly to the elementary school and high school student have been obtained by several local ARS sections. Programs conducted by the Antelope Valley Section of California and the Central Colorado Section over the past two years have demonstrated that these students need and hunger for more basic science; that teaching talent of the caliber and unselfishness to satisfy this need can be found among the professional membership of the ARS, and that the local section organization can bring them together.[5] Furthermore, these programs indicate considerable success in replacing the lure of sensationalism in live rocketry with a healthy interest in objective science.

Such programs face the situation, but do not truly solve it. Striking at one of the causes itself, the Palm Beach Section established a 30-hr lecture series in basic astronautical sciences for the high schol teacher.[6] Though fully accredited, many with Master's and Doctor's degrees, the large majority of the teachers there had poor or no mathematics background, and most found lectures such as "Elements of Propulsion" too difficult to comprehend, preferred philosophical discussion to a mathematical presentation. The problem of establishing a proper educational atmosphere for the youth who will inherit tomorrow's world of science is complex indeed.

To approach this problem once again for the ARS was the object of the Youth Program Workshop, a conclave of some 20 representatives from industry and educational circles who met at Princeton Univ. late in September. More will be heard from this group.

Evaluating the Goals

Evaluation of the aims and goals of education has been of foremost interest to many outstanding thinkers in this country even before October 1957. The ascendancy of Russian prowess simultaneously in astronautics hardware, science, and education has intensified awareness in this country that a re-evaluation of our scientific and engineering education is necessary. It has also become clear that it is no longer sufficient to modify curricula or course content, but that a thorough search for a valid educational philosophy is needed. Probably the most eloquent document expressing this need is the report of the President's Science Advisory Committee, "Education for the Age of Science."[7] To quote from this report:

". . . No one in the United States denies that we should have a first-class system of formal education. But not everyone realizes that the strength and happiness, even the survival, of our democratic society will be determined primarily by the excellence and the appropriateness of our educational patterns . . .

". . . Our changing civilization will demand in the future an even greater devotion to learning and a greater pride in intellectual achievement. The profound effects of recent advances in science and technology demand that scientific literacy be far more widespread among the American people if we are to solve the problems of this age . . .

". . . Four major areas need specific and urgent attention throughout our educational system: (1) The curriculum and the content of courses, (2) the quality and effectiveness of teachers, (3) the recognition and encouragement of students, and (4) development of intellectual leadership. . ."

Numerous other cogent and stimulating conclusions were reached by the President's Science Advisory Committee. The entire problem will be

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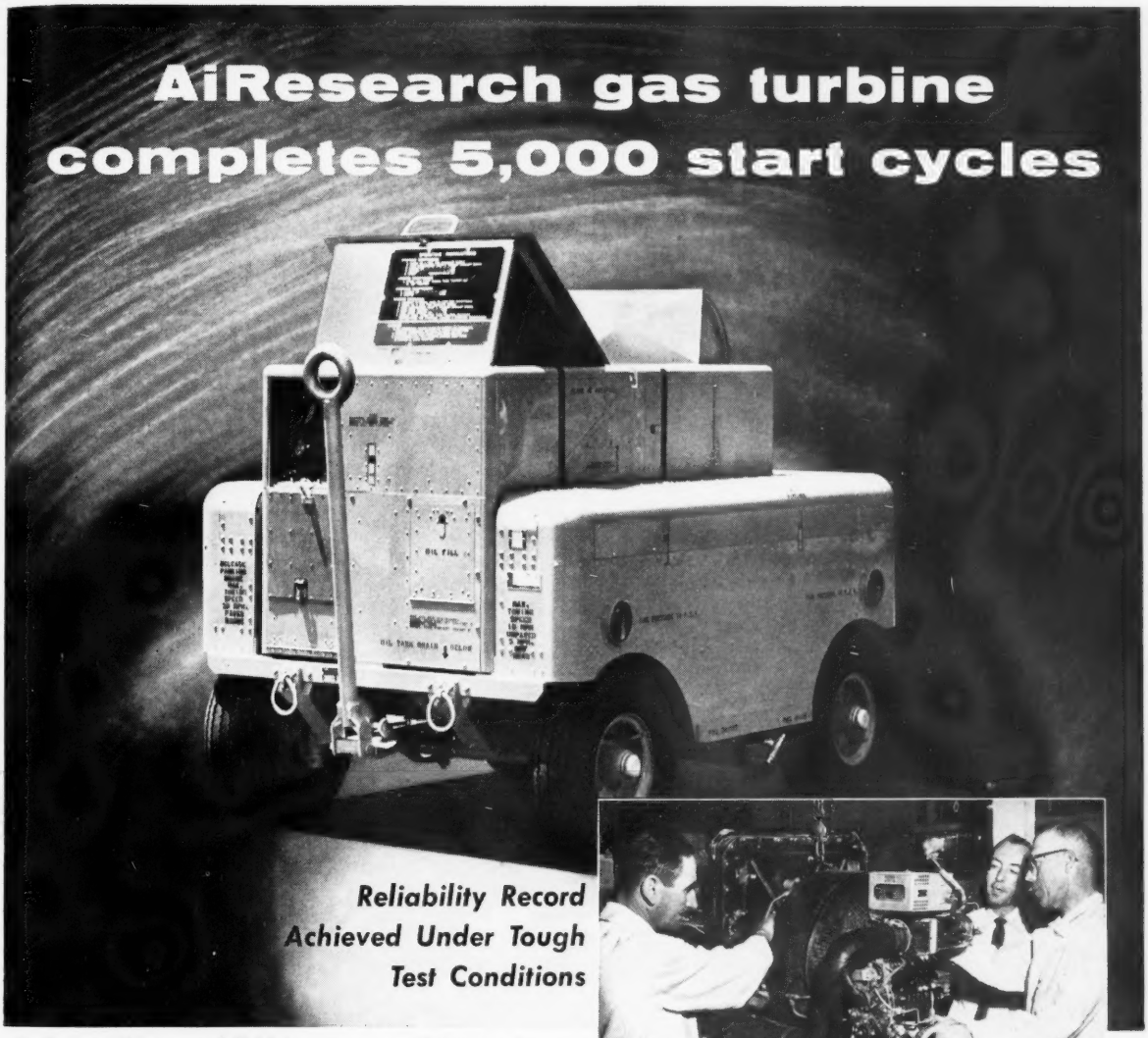

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the topic for a panel discussion by a group of outstanding men in education, science, and sociology at the Education Session of the ARS National Meeting in Washington this month.

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"Engineering Education Exchange Mission to the Soviet Union, Final Report," Am. Soc. for Eng. Education, *Journ, Eng. Ed.*, vol. 49, no. 9, May 1959, p. 839 (deals with education in general rather than with astronautics, because of the nature of the mission).

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Magnetohydrodynamics

(CONTINUED FROM PAGE 40)

of "hash" and no longer reproducible. In such devices as the pinch, the advent of this kind of instability did not seem to be uniquely related to the interface instability which had been explored earlier.

Some scientists had done enough thinking about the results to offer some ideas on an interpretation. These included "runaway electrons," "cooperative effects," "magnetohydrodynamic turbulence," "plasma oscillations," "magnetic field diffusion," etc. But offering a name, and offering an understandable explanation which fits the observations, proved to be two different things. Therefore, the consequence of the Geneva meeting seemed to be to slow down previously rapidly expanding work on fusion devices and to initiate more fundamental research on ways to understand the behavior of a plasma in a magnetic field.

The concern about plasma instabilities caused a number of scientists to give considerable attention to plasma oscillations. The possibility of oscillation due to local separation of charge and the consequent restoring force has been known for some time. One of the problems was to discover how the random particle energy could be converted to wave motion that might carry the energy to the boundary of the plasma. If an electric field carries an interstreaming of electrons and ions, it has been predicted that such oscillations should grow. Our knowledge has increased considerably on the conditions which lead to growth or damping of waves, and this has been given in a review paper by Jackson.[4]

Suggested an Analogy

The sudden change from reproducible outputs to random-type signals from a confined plasma suggested an analogy with the transition from laminar to turbulent flow. Most plasmas have such low density that the mathematical treatments usually neglect the collisions. Superficially, this would lead one to discount the possibility of turbulent plasma vortices. Kovasznay[5] has taken a closer

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look at the magnetohydrodynamic equations and seen a possibility that the plasma energy may be transformed into a form of turbulence which is analogous to fluid-mechanical turbulence. The chief problem seems to be to find a method of measuring the turbulent fluctuations that can do for magnetohydrodynamic turbulence what the hot wire did for fluid turbulence.

Over the past several decades, the hydrodynamicist has added thermodynamics and chemistry to his studies so as to encompass propulsion and combustion. After encouraging ionization in hypersonic flow, aerodynamicists began to add Maxwell's equations to the list. A number of areas of interest developed. The so-called plasmajet or arcjet, which uses gas flow to confine and intensify the arc, proved useful as a source of high-temperature gas with tens of thousands of degrees Kelvin range. Materials testing facilities and high-temperature wind tunnels have been built. There was a flurry of interest in the arcjet as a means of propulsion, but the high specific impulse obtainable from the ion-rocket seemed to more nearly fit the optimum requirements for space travel. There is a possibility of revival for use in space maneuvering, where somewhat higher thrusts may be desired.

Turned to Use of Arc

The aerodynamicist quickly turned to the use of arc and magnetically driven shock tubes to produce shock Mach numbers above those readily produced by the pressure-diaphragm shock tube. Mach numbers of 40 in air are obtainable with relatively simple apparatus. The magnetically driven shock tube also suggested a means of space propulsion with a specific impulse in the optimum range indicated for foreseeable space power supply units. The difficulties encountered with charge neutralization of ion beams have caused a number of investigators to turn their attention to plasma-propulsion units. There is a growing feeling that the plasma-propulsion unit should be of the electrodeless type, with the plasma currents induced by traveling waves. The presence of the electrodes would make it difficult to obtain the high specific impulse.

On the analytical side, the aerodynamicists first began to investigate solutions with infinite conductivity. Concern about the relatively low conductivity of the hypersonic flow at re-entry speeds stimulated the study of solutions with low conductivity or Magnetic Reynolds Numbers. More

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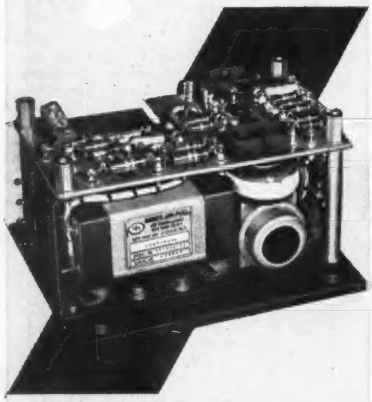

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recently, solutions have been attempted with finite conductivity.

One of the first applications which grew out of the analytical studies was possibility of reducing the heat transfer about a bluntnosed re-entry body. Of the two parts to the problem, namely the effect of the magnetic field on the shock layer[6] and the effect on the boundary layer, the former produces the most significant part of the change.[7] Other studies on boundary-layer flows began to indicate some startling effects. Bleviss[8] found from Couette flow studies that in the re-entry velocity range rapid changes of conductivity as a function of local temperature should cause sudden dramatic changes in the heat transfer and skin friction. In the meantime, one-dimensional flow studies and other studies with special simplifying assumptions have helped to gain an insight into some of the characteristics of magnetohydrodynamic flow.

Analyzed Combinations

Of course, the aerodynamicist would be interested in the effects of magnetic fields on the flow of conducting fluids around airfoils. Sears[9] and his colleagues have done an excellent job in analyzing the various possible combinations. The propagation of disturbances at both sound speed and Alfvén wave speed lead to some very unusual results, particularly when the Alfvén waves produce upstream effects in supersonic flow.

At present, there is a rapidly growing body of magnetohydrodynamic flow solutions. Almost none of these has had any experimental verification. There has been no way to establish a basis for knowing which of the simplifying assumptions necessary to obtain solutions will lead to the most useful results. Unfortunately, careful experiments in magnetohydrodynamics are very difficult to make, and verification of the theories may come slowly.

On the other hand, as a body of substantial knowledge is built up, it would seem reasonable to predict that ceilings on flow velocity and temperatures will go up by at least one and two orders of magnitude. If so, many fruitful applications will emerge.

Finally, it is interesting to note that magnetohydrodynamics appears to offer new areas of studies to many fields of science and has already served to bring research workers in these fields closer together.

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Nuclear Propulsion

(CONTINUED FROM PAGE 42)

so far indicate that superperformance reactors would most likely be gaseous reactors. On the other hand, many difficult problems must be solved before the feasibility of gaseous reactors can be established.

According to an announcement by the AEC, a radically new concept is being explored to utilize nuclear energy for propulsion. The essence of this concept is to impart momentum to a vehicle by exploding nuclear bombs underneath it. This idea may lead to very important developments in rocketry, although many technical problems involved are obviously formidable.

In the area of nuclear-power development for auxiliary power systems, the project known as Snap has been meeting successes and shows a great deal of promise. Undoubtedly, results achieved in this project will also be useful in future applications of nuclear power to advanced propulsion.

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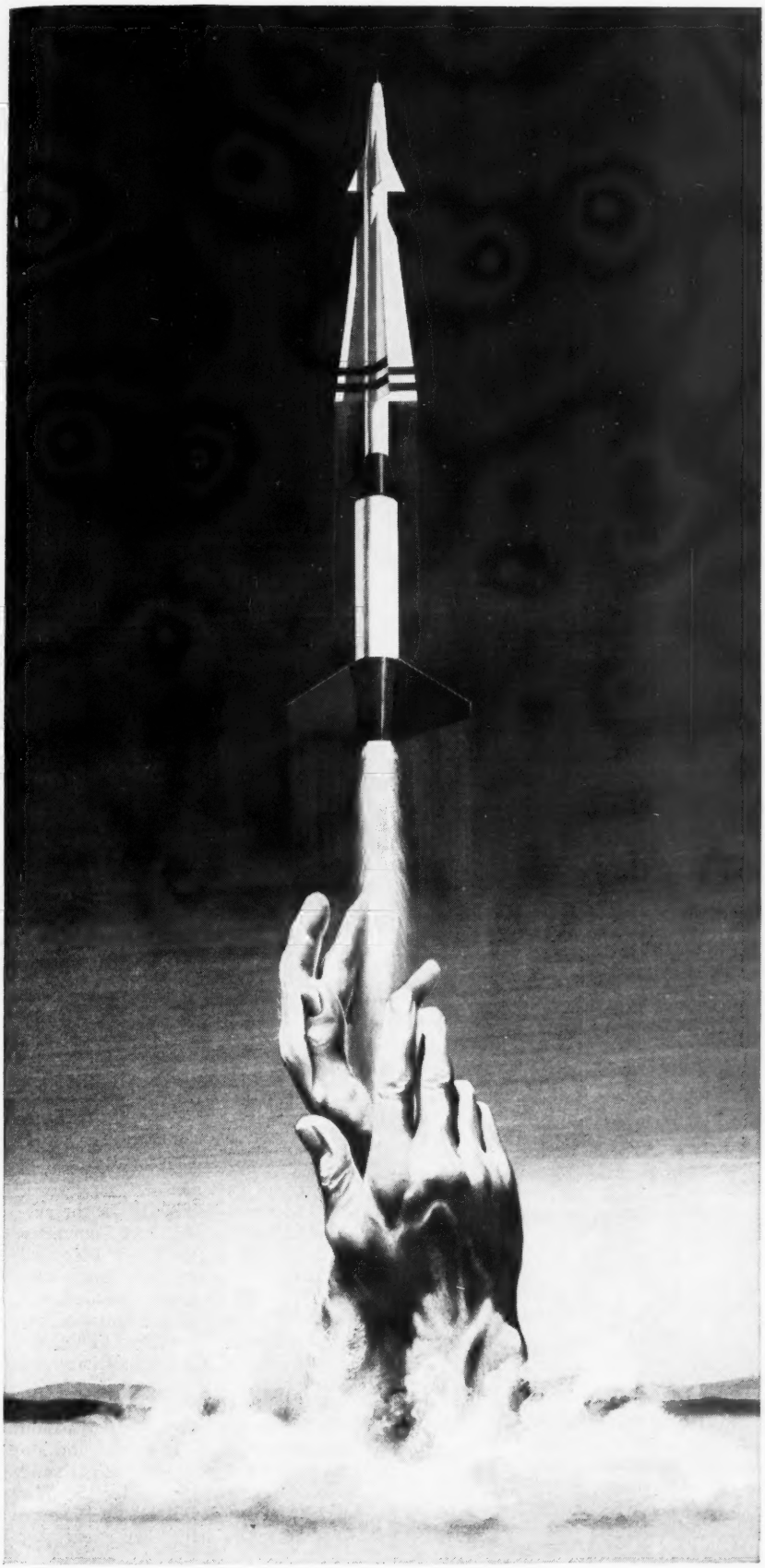

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1917	LINDE became a part of UNION CARBIDE
1918	Operations extended to Canada
1922	Began commercial production of neon
1928	Started development of system for liquid oxygen and nitrogen
1932	First customer liquid oxygen storage and conversion unit installed
1932	First liquid oxygen truck delivery to customer units
1935	High-pressure conversion equipment adapted to truck use
1937	Powder-vacuum insulation reduced heat leak to contents by a factor of 10
1939	First vacuum-insulated railroad tank car shipment of liquid oxygen
1944	Liquid oxygen producing plants, transport containers, and storage units made for government
1946	Basic patent for powder-vacuum insulation issued
1946	First 25,000,000 cu. ft. liquid storage reservoirs for oxygen, nitrogen, or argon
1948	First 140 ton a day low-purity oxygen-producing unit
1949	First 360 ton a day on-site oxygen-producing unit for chemical industry
1951	Heat leak to contents further reduced by a factor of 10
1953	First 450,000 cu. ft. capacity vacuum-insulated trucks
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1957	3000 cu. ft. cylinder adapted to shipment of liquid nitrogen, argon, and hydrogen
1957	Continuing progress in decreasing heat leak to contents
1957	Liquid oxygen distribution system requiring no external power source
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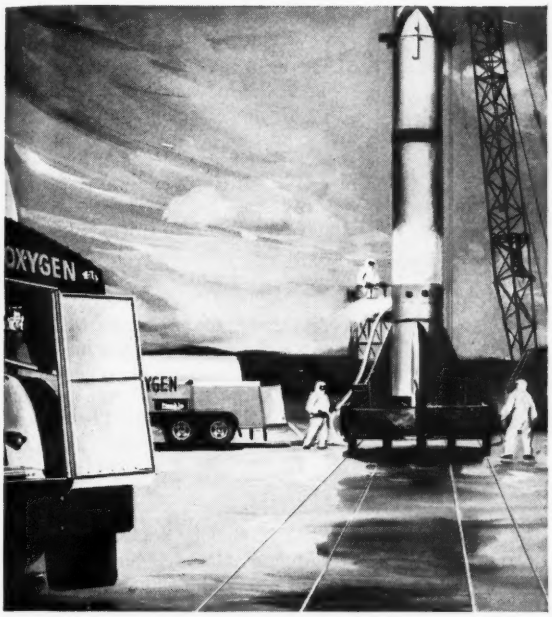

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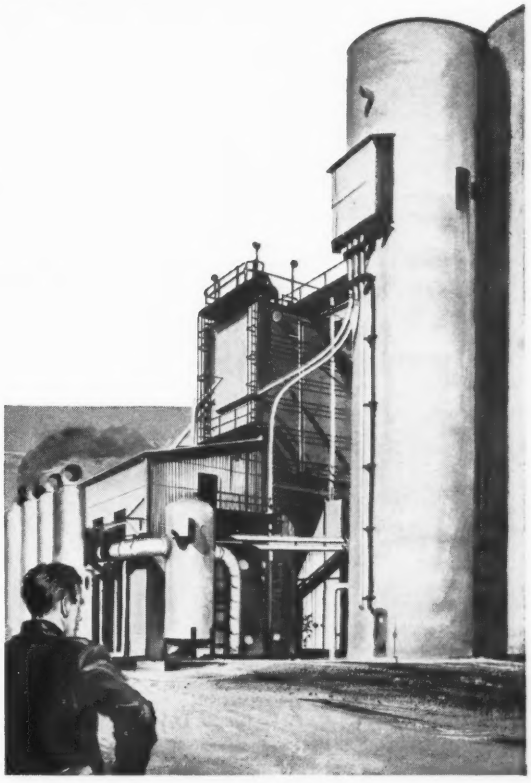

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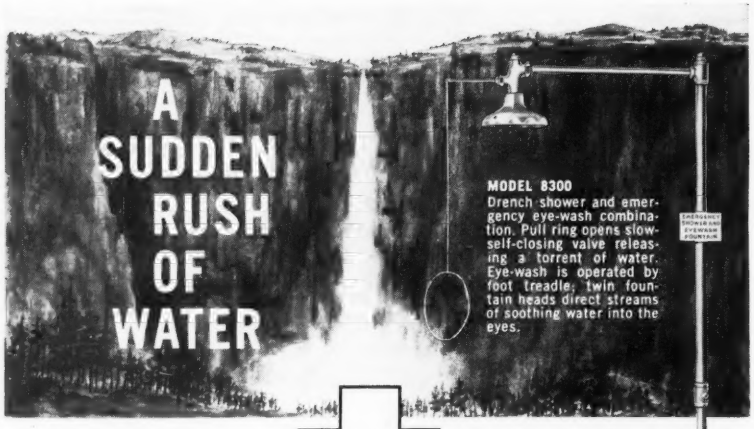
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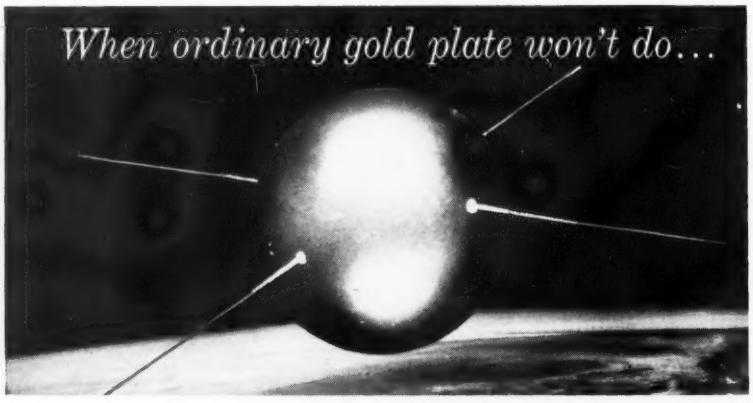

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Space Law and Sociology

(CONTINUED FROM PAGE 48)

Subcommittee was composed of Representatives Victor L. Anfuso, chairman; Leonard G. Wolf; Walter H. Moeller; Ken Hechler; David S. King; Gordon L. McDonough; and Spencer M. Beresford, counsel. Rep. Anfuso spoke at the luncheon recess and Rep. King, Moeller, Hechler, and Wolf, and Mr. Beresford spoke during the sessions. Remarks of Rep. Anfuso were placed in the *Congressional Record* by Rep. John W. McCormack.

Second, diplomatic personnel from Eastern European nations attended the meeting, including V. A. Kuznetsov, counsellor, and V. I. Oberemko, first secretary, of the Permanent Mission of the U.S.S.R. to the UN, and Jacek Machowski, counsellor, Permanent Mission of the Polish People's Republic to the UN. Machowski delivered a paper entitled "Problems of Space Law at the 13th Session of the UN General Assembly."

Third, university professors and jurists and sociologists from throughout America attended this Conference which constituted, in reality, the first great conference on the social sciences relating to astronautics. The effort was duplicated to a lesser degree in San Diego by the holding of the Space Law and Sociology Committee meeting on June 9, 1959.

The papers read and the facts developed at these Conferences undoubtedly were most helpful to the members of the UN Legal Committee, because their Report, dated June 12, 1959, re-expresses in somewhat attenuated form the views covered in the IAF and ARS meetings outlined previously.

Priming the Pump

It is also interesting to note another parallel development: During the fall of 1957, Welf Heinrich, Prince of Hanover, and the writer lectured at 26 American universities and at numerous European universities on "The Law of Outer Space." Following these lectures, the American Bar Assn. organized a Committee on the Law of Outer Space with David F. Maxwell (then retiring president of ABA) as chairman and the writer as vice-chairman. This Committee has been quite active over a period of two years. The American Bar Foundation received a grant from NASA for the purpose of supporting research by this Committee and the compilation of a report. The task was assigned to Nicholas Katzenbach of the Univ. of Chicago and Leon Lipson of Yale Univ., and the report was submitted and

The True Test of Capability

Not too long ago an editorial roundup on inertial guidance and navigation had an interesting quote: "An inertial guidance system is like a baby. It's easy to conceive, but difficult to deliver."

The truth of this observation may have been lost in the midst of claims and counter-claims that have characterized the field since inertial guidance was accepted as feasible in 1949. But these claims have not altered the fact that *delivery of a reliable inertial system remains the true test of capability.*

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It is this *understanding* of things inertial that the Sperry team of scientists, engineers and production specialists can bring to the *delivery* of new inertial advancements for manned aircraft, space vehicles and for missiles and rockets. The B-58 bombing-navigation system is a development and product of Sperry's Air Armament Division, Sperry Gyroscope Company, Division of Sperry Rand Corporation, Great Neck, New York.

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SPERRY

approved at the August 1959 meeting of ABA in Miami.

It is quite impossible to discuss the ABA report in this brief summary of the year's developments. The report is somewhat more satisfactory than the attenuated UN document cited above, but, as pointed out by the dean of commentators on space law, John Cobb Cooper, in referring to the conclusions of the report: "Of much greater importance to me are the sections of our Committee report dealing with the problem of air space and outer space boundaries. The body of the report seems to imply that this is a purely theoretical question not now urgent and which in fact may never need to be solved.

"With this point of view I most vigorously disagree. As stated earlier, the report recognized the existence of two finite areas. In one of these, called the 'air space,' which is adjacent to the earth, sovereign states have complete, absolute, and unilateral rights to control the entry or movement of all flight instrumentalities whether national or foreign. In the other area called 'outer space,' certain freedom should exist for all . . .

"To me, it is a most practical and urgent question that there be early international agreement defining these areas. The problem presents more dangerous possibilities than the fixing of the boundary between national marginal seas and the high seas. Yet states in the international community have deemed it urgent to agree to those boundaries. If discussion of the limits of air space and outer space is too long delayed, the problem will rapidly become almost insoluble. I am not prepared to agree to any statement which countenances such delay or minimizes the serious consequences that may ensue." The writer officially concurred with the viewpoints of Prof. Cooper.

Second Colloquium

A final major development must be mentioned. The Second Colloquium on the Law of Outer Space of the International Astronautical Federation was held at historic Lincoln's Inn in London on Sept. 4, 1959. Chairmen of this Colloquium were Christopher Shawcross, Q.C., world-renowned British lawyer, and Prof. Cooper. Co-chairmen included Rep. Anfuso, Luis de Gonzaga Bevilacqua (Brazil); Fritz Gerlach (Germany); D. Goedhuis (Netherlands); Robert Homburg (France); Manfred Lachs (Poland); Alex Meyer (Germany); E. Pépin (Canada); H. Safavi (Iran); Michel Smirnoff (Yugoslavia); and F. W. von Rauchhaupt (Germany). More than 30 papers were presented by eminent lawyers and sociologists from more than a score of nations.

The Permanent Legal Committee of the IAF was reconstituted into the Institute of Space Law of the IAF, and an organizing committee set up consisting of Christopher Shawcross as chairman; the writer as executive secretary; and Prof. Cooper, M. Homburg, Dr. Gerlach, and Dr. Smirnoff. In addition, the writer was elected general counsel of the IAF itself, with authority to serve as ex officio member of all IAF Committees and with the directive to appoint working groups to study and report on specific space law problems; and finally, to continue to represent the IAF before all sessions of the International Telecommunication Union in matters pertaining to the use of the radio spectrum for astronautics purposes (see page 20).

The truly happy marriage of the social and natural sciences was strikingly exemplified in Moscow on Sept. 14, 1959, when the writer (a social scientist), retiring IAF President, heard his successor, Leonid I. Sedov (a natural scientist), disclaim Russian sovereignty over the moon as a result of the successful U.S.S.R. moon shot. The natural scientist bespoke the juridical philosophy of his colleague!

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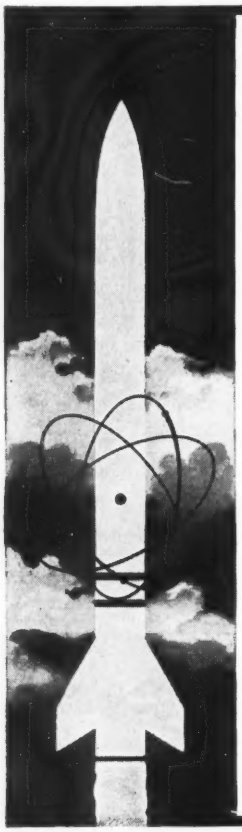

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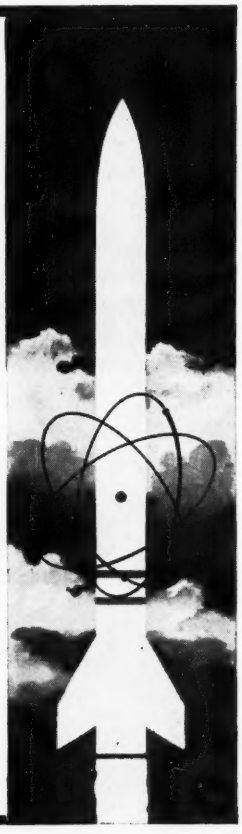

NO MONDAY MORNING QUARTERBACK

Good management, like a good quarterback, calls the right signals during the game and not on Monday morning. In the field of aviation and space, management must also call the right signals now for a game that won't be played for years to come.

At Grumman, the signals have already been called for nuclear propulsion systems, for the plasma harnessing of hydrogen fusion, for missiles, for hydrofoil seacraft, and for others still classified.

At Grumman, the signals that were called years ago have won design competitions: the A2F, a carrier-based attack fighter; the Mohawk, a twin turboprop higher-performance observation airplane for the Army; and the Eagle, an air-to-air and air-to-ground missile. At Grumman, Monday morning is the beginning of the future.

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Improved Tracking System For Atlantic Missile Range

Plans for an improved tracking system, capable of measuring changes in missile position of one-tenth of a foot at distances hundreds of miles down range from Cape Canaveral, have been announced by Maj. Gen. Donald F. Yates, AFMTC Commander. The system, called Azusa Mark II, will also give the Atlantic Missile Range improved tracking potential at ranges to the moon and beyond.

Gen. Yates' announcement came after the award of a $1.7 million contract to Convair-Astronautics for installation of the system, which it designed and built. It will replace the original Azusa system, used to track missiles at the range since 1954, and will be ready for operation as range equipment next year.

Solid Rockets

(CONTINUED FROM PAGE 47)

plicity, and flexibility. This research and development work has not impeded the constant effort to improve specific impulse and mechanical properties with existing propellants. Two to three per cent is the normal annual increase in specific impulse, which is now above 250 sec. Some of this added impulse must be attributed to the use of lightweight metals which have increased flame temperatures.

One of the bonus items which emerged from the use of lightweight metals to increase specific impulse was the overcoming of the so-called "plague" of the solid rocket industry since its earlier days, i.e., resonant, or unstable, burning. Research at Acoustica Associates Inc. and Georgia Tech, according to reports, indicates that this phenomenon, if controlled, can be utilized to control the burning rate of the propellants and may be a breakthrough in the throttling of solid rockets.

Mechanical Properties

One significant trend in propellant chemistry is the consideration being given to propellant mechanical properties, which up to this time were considerations secondary to specific impulse. With the cast-in-case, case-bonded propellant grains, mechanical properties have been found to decrease when compared to a free-standing propellant grain. Of what avail was an increase in specific impulse if the propellant would not adapt to the wide temperature limits to which the finished rocket motor is exposed?

This question—actually long a challenge to chemists, stress analysts, and physicists—may now be resolved, and the secret to very large solid rocket motors may have been found. For example, according to reports, Atlantic Research Corp. has significantly extended present firing-temperature limits.

Continuous Mixing

This year has also found all major propellant developers concentrating on the process of "continuous mixing" of propellants. If a propellant were developed which could be cured without the application of heat and continuously mixed, it would afford a tremendous on-site loading capability. This is of particular merit for very large rocket motors.

Indications are that the mass (propellant) fraction may increase from the present maximum of 0.92 to 0.95. This advancement in mass fraction will be realized through the efficient utilization of improved inert-part materials, such as steel, titanium, and Fiberglas. The steel companies are concentrating on materials with tensile strengths up to 300,000 psi. Concurrent programs are being conducted for maximum utilization of these materials, i.e., maintaining their full strength during processing.

Titanium processing for use in rocket chambers and nozzles is being studied by at least two major companies. The major hurdle with titanium as with steel is the development of full strength after processing, welding, and forming. This year will probably see the use of some small titanium cases.

The most serious problem limiting the strength of metallic inert parts is that of "notch sensitivity," which affects large units by causing failure during hydrostatic testing. Even after extensive X-ray or magnetic-particle testing, a notch is not always detected. The phenomenon and its cure are being studied by structural and metallurgical specialists.

Young Div. of Hercules Powder Co. has been investigating the use of Fiberglas as a primary inert-parts material. This type of construction is being considered for use in some of our larger units. All-Fiberglas nozzles, in addition to rocket chambers, have been developed and tested, utilizing end-grain Refrasil with very little erosion during fairly long burning times.

A serious limitation on present-day propellants is the lack of suitable materials for nozzles. Preliminary studies have indicated the feasibility of utilizing various methods of nozzle cooling. Some of the systems being studied involve secondary propellant charges, transpiration, film cooling, and supplementary heat sinks. However, much concentrated effort must be applied before these studies can provide an efficient solution to the nozzle problem.

Chamber liners still are under constant scrutiny from an efficiency and reliability standpoint. Astrodyne reportedly has a rubber and asbestos liner that gives high protection from some of the present-day high-temperature propellants over a long burning time (in excess of 3 min). However, the mechanical properties of the liner and its ability to bond to propellant and chamber must be constantly reevaluated before new propellants can be used on production motors.

Very little information is available on the progress of the Minuteman, Pershing, and Polaris rocket systems except that the last is now in flight-testing status. It must be presumed that the first two are undergoing normal development problems which require only time to resolve.

The future does look promising for this fast-moving industry. True, there are problems which must be solved by the concentrated effort of chemists, physicists, structural designers, ballisticians, and the whole host of scientists. Some of the important areas are the development of high-energy fuels and oxidizers (including metal hydrides), more efficient thrust-level control, and vector-control methods.

Major Problems Solved

Aerojet is reportedly spending a quarter of a million dollars in the development of a rocket motor which will deliver a thrust of a million pounds for more than 30 sec. Such a program would indicate that they feel most of the major problems have been solved or at least have been resolved into a group of relatively minor items.

The ARPA budget indicates that there will be a development program for a million-pound-thrust rocket motor. This is a step in the right direction. It is hoped that all the design requirements will be met, since they will lead to larger and more efficient rocket motors for use in some of our larger space vehicles.

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DISCOVERER ORBITS WITH A PUSH FROM BELL AIRCRAFT

Scientific exploration of space is being conducted with the *Discoverer* satellite to prepare the way for man's eventual flight into orbit and beyond.

Bell Aircraft's rocket engineers have developed and built the 15,000-pound thrust rocket engine which gives *Discoverer* the final boost into orbit and, its job done, circles the earth with the satellite.

Using unsymmetrical dimethylhydrazine and red fuming nitric acid as propellants, the Bell engine demonstrates the highest possible performance of any rocket engine in its thrust range.

This small but powerful propulsion unit is one of the products of Bell's extensive experience in the field of rocketry spanning a period of more than 15 years. Bell engineers also are doing important developmental work with fluorine for the Air Force.

The *Discoverer* engine is provided under sub-contract to Lockheed, which is building the satellite for the Advanced Research Project Agency.

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Hot Gas Generator Spin Stabilization System

A hot gas generator spin stabilization system designed for use in the Navy's Polaris missile has been developed by Garrett Corp.'s AiResearch Mfg. Co., 9851 Sepulveda Blvd., Los Angeles for the Lockheed Missiles and Space Div.

Weighing less than 3 lb, the system consists of a high-energy solid-propellant gas generator and two supersonic thrust nozzles with appropriate tubing for installation within a given envelope. The generator incorporates electric pyrotechnic ignition, a time delay, and a composite-base propellant in a single cartridge, with a 4-in. cylinder of propellant ignited after a specified time delay and burning at a pressure of 1000 psi and with flame temperature of 3000 to 4000 F for 0.2 sec.

Liquid Rockets

(CONTINUED FROM PAGE 38)

extensive testing of the entire engine is undertaken.

So far as decreasing the large number of major components is concerned, it is obvious that simplification of the entire engine system is in order. In this regard, pressurization systems to replace the conventional turbopump system are mandatory. Low chamber pressure operation will result in the use of pressurized units rather than turbopumps. It is easy to prove that operation at 100 psia chamber pressure, or below, will result in increased reliability even though it increases weight. The tradeoff between weight and reliability deserves serious consideration.

In the area of propellants, established combinations in current use or development are lox and RP-1, lox and hydrogen, N_2O_4 and hydrazine, and minor variations thereof. Some of these are storable, others cryogenic. It is pertinent to point out that propellants contribute in a large measure to the reliability of a rocket engine. Cryogenics usually require added handling otherwise not needed for storables. Low temperatures associated with cryogenics represent areas of unreliability. In general, the cryogenics yield better performance in terms of specific impulse than storables. The table below gives the performance of some selected cryogenic and storable combinations.

The table includes only those combinations that yield a specific impulse greater than 250 sec. Bulk density is included because of its importance in determining the mass ratio of a vehicle. It is seen that there are storable combinations having comparable specific impulse and higher bulk density than lox and RP-1.

Advantages of Storables

Although there are valid reasons, such as relatively low cost and accumulative experience to use lox and RP-1 for our current programs, the fact that storable combinations such as N_2H_4 and ClF_3 possess advantages from the standpoint of specific impulse and bulk density cannot be minimized. While admitting we do not have sufficient experience in the use of such combinations at present, it is believed that for future generations of liquid-propellant rockets storable combinations might well be selected, at least for the booster stage.

Again it must be pointed out that the tradeoff between performance and reliability must be given serious attention, and it is believed here that reliability should supersede other considerations.

In any event, it is obvious that an advanced research project on liquid propellants equivalent to Project Principia on solid propellants is of sufficient importance to future space programs to warrant integrated investigation by the rocket industry.

PROPELLANT PERFORMANCE

Nonstorables

Fuel	Oxidizer	Specific Impulse (sec)*	Bulk Density
H_2	F_2	362	0.41
H_2	O_2	349	0.25
N_2H_4	NF_3	294	1.37
NH_3	F_2O	292	1.10
$Al(BH_4)_3$	O_2	291	0.78
MMH	O_2	272	1.0
RP-1	O	261	1.0

Storables

N_2H_4	ClO_3F	262	1.29
N_2H_4	ClF_3	260	1.51
UDMH	ClO_3F	254	1.27
UDMH	N_2O_4	251	1.17

*300 psia and 14.7 psia exhaust pressure

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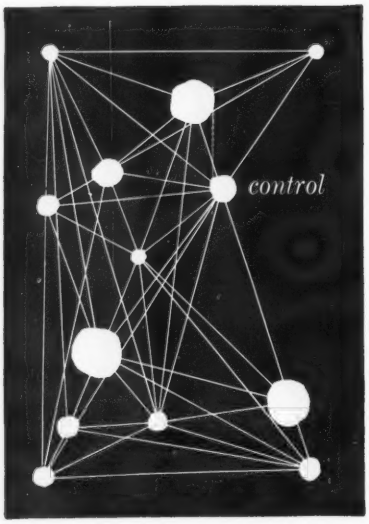

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Guidance and Navigation

(CONTINUED FROM PAGE 33)

weapon delivery control, navigation; and cruise control. To top off such amazingly versatile capabilities, provision is generally made for automatic inflight self-checking. These rapid developments in the art of data processing and computation will fulfill in timely fashion the requirements for navigation in space.

Further extensions of digital capabilities are insured by a healthy backup of component improvement and research. Improved production techniques are increasing the reliable ranges of transistors in power, frequency, and temperature. Micromodules (comprised of microelements) now under development may yield a 10:1 reduction in size under present transistorized circuits. Researchers are also working on reducing component unreliability and size by eliminating the component as such. This they hope to accomplish by a rather diabolic game called molecular electronics, or "moletronics." This new school of science includes rearranging the array of atoms and ions within a pure single crystal of material to produce a synthetic material with desired electrical qualities. The specified irregularities of atomic alignment are achieved by a systematic introduction of impurities or structural imperfections. It may soon be fashionable to engrave the Lord's Prayer on the head of an amplifier.

Atomic Clock Development

To change the subject, what improvements are being made in the navigator's chronometer? You can't navigate on the earth's surface, below it, or above it, and certainly not in space, without a good clock. Advances in this area center about progress in the development of atomic clocks.[8] Work on these ultraprecise frequency standards is proceeding to a point where packages of usable proportions for airborne and space use can be foreseen. Accuracy, including stability and reproducibility, is generally forecast to be between 1 part in 10^9 and 10^{10}.

These devices use gaseous atomic resonances, responding to a minute range of frequencies, to stabilize the frequency of an electronic crystal oscillator. Accuracy is determined by the ratio of the frequency range to the resonant frequency. In addition to uses in military and astronautic navigation, these clocks are being booked for some interesting scientific experiments. By orbiting them at various heights and comparing them to terrestrial timepieces, it is intended to check both special and general theories of relativity. Further experiments are planned to check velocity of light and gravitational phenomena.

The guidance and navigation fraternity has been busily engaged in planning for its role in space travel.[9-13] This is stimulating exercise and will provide a good bag of tricks to be used when they are needed, which, following an historic pattern, will be when our flamethrowing brethren of propulsion addiction can supply the power. In the meantime, we try to maintain our sense of humor[14] and hope for the best.

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Eagle Missile Contractors

The Navy's air-to-air Eagle missile system will be developed by the following industry group headed by prime contractor Bendix Aviation: Grumman Aircraft Engineering Corp., airframe, propulsion, and launching systems, and some ground equipment; Sanders Associates Inc., guidance elements; Litton Industries, tactical computer; and Westinghouse Air Arm Div., airborne intercept radar.

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"Application of Computer Simulation to Production System Design," a paper by Allen J. Rowe, is available upon request. Send request to Dr. Rowe at SDC.

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Technical Program

(CONTINUED FROM PAGE 61)

boosters, advances in static testing, ignition systems, and design considerations for the use of spiralloy glass-reinforced filament-wound structures as rocket inert parts. The classified ramjet session will include papers on ramjet power for supersonic low-altitude vehicles, direct flying costs of ramjet aircraft, and performance of liquid-fuel ram-rockets.

Four sessions on the morning of Wednesday, Nov. 18, will deal with structures and materials in near-space, current problems of space travel, test facilities and ground-support equipment, and miniaturization. Meanwhile, a Secret session will be devoted to a survey of storable propellants and combustion oscillations.

The structures and materials session will deal with simulation of environmental conditions in near-space, surface behavior in near-space, materials in energy-conversion systems, and development of the Project Mercury capsule pressure vessel, while the space-flight session will feature a discussion on the comparative advantages of high- vs. low-thrust vehicles, radiation problems in low-thrust flight, and survival equipment for emergencies.

The missile and GSE transportation environment, a look at the moon from the standpoint of support-equipment designers, ion-engine test lab planning, and altitude-facility rocket testing will be discussed in papers scheduled for presentation at the test facilities session, while the miniaturization session will feature papers on space computers, data recovery, semiconductor solid circuits, macromodules, and molecular engineering.

Propulsion Sessions

Afternoon sessions will be devoted to plasma propulsion (with seven papers scheduled for presentation), recoverable boosters, payload instrumentation, and liquid rockets. The recoverable booster session will highlight a special panel discussion on the subject, as well as papers on the economics of recoverable two-stage orbital carrier vehicles and characteristics of winged recoverable boosters. The instrumentation session will deal with such subjects as atomic clocks; aspect sensing, astrostat design, and orientation control; and instrumentation for magnetic-field studies. A 6000-lb-thrust nitrogen tetroxide-hydrazine system, high-discharge pressure hydrogen pumps, and single- vs. multiple-chamber boosters will come up for discussion at the Confidential session on liquid rockets.

A second space law and sociology session, a session on power systems, and the first of two Secret sessions devoted to recent advances in nuclear propulsion are on the agenda for Thursday morning. Nine papers will be offered at the space law session, with five scheduled for the power system session. The nuclear propulsion session will spotlight the first papers on Kiwi-A design details and testing.

Second power system and nuclear propulsion sessions round out the technical program on Thursday afternoon. The power system session will feature papers on solar heat-to-electricity conversion, regenerative fuel cells, space power stations, and basic energy conversion in space vehicles.

It is interesting to note that, of the 105 unclassified papers scheduled for presentation at the meeting, more than two-thirds are directly concerned with astronautics and space research or experimentation. The breadth and scope of the Society's activities has never been more clearly indicated than in this technical program.

Even this brief rundown of the program will serve to indicate that it is something no engineer or scientist who is working in the field of astronautics or rocketry can afford to miss. ♦♦

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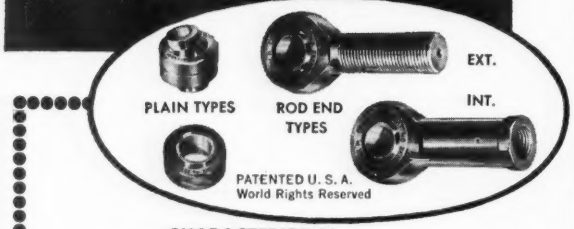

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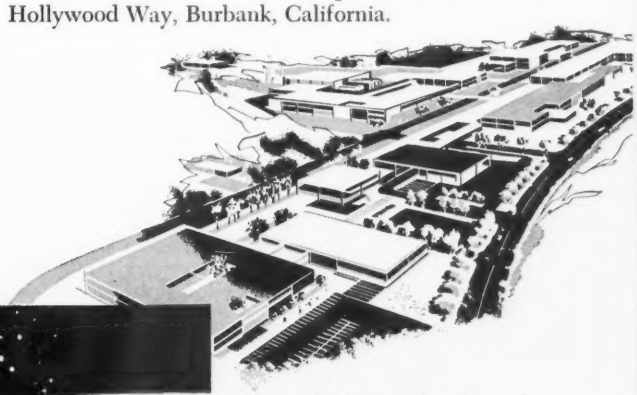

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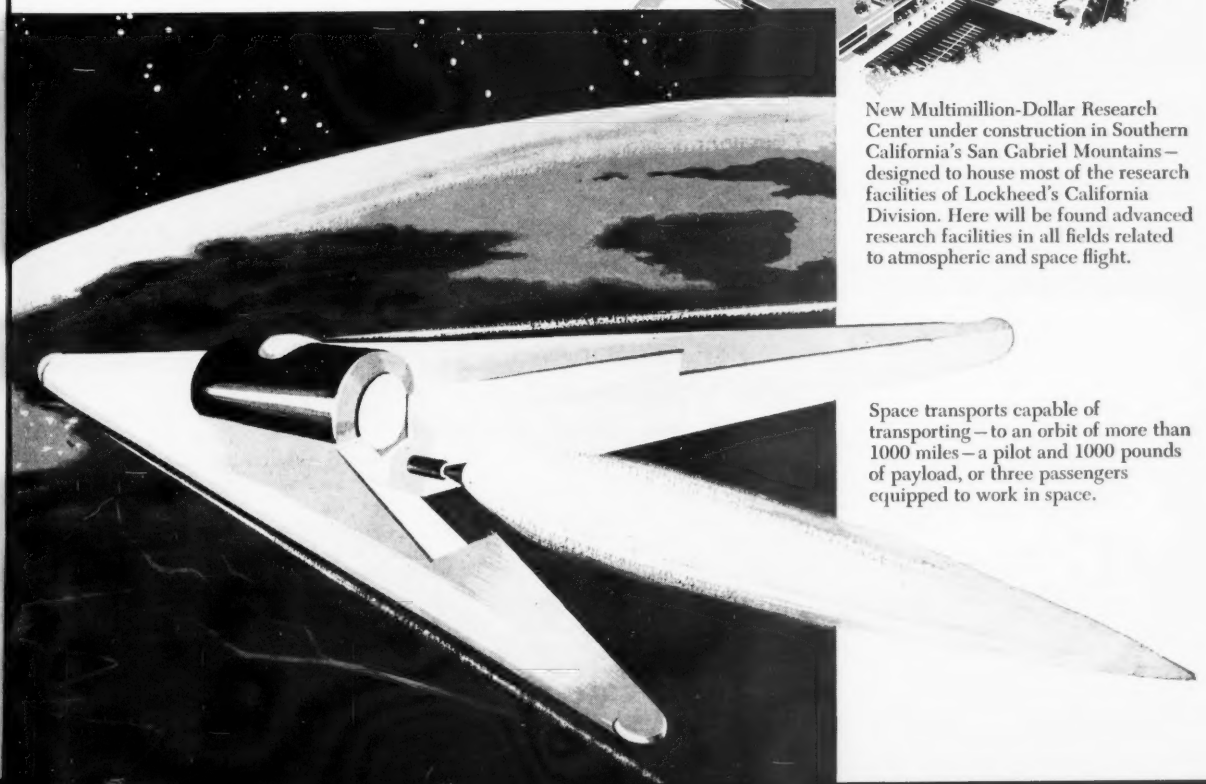

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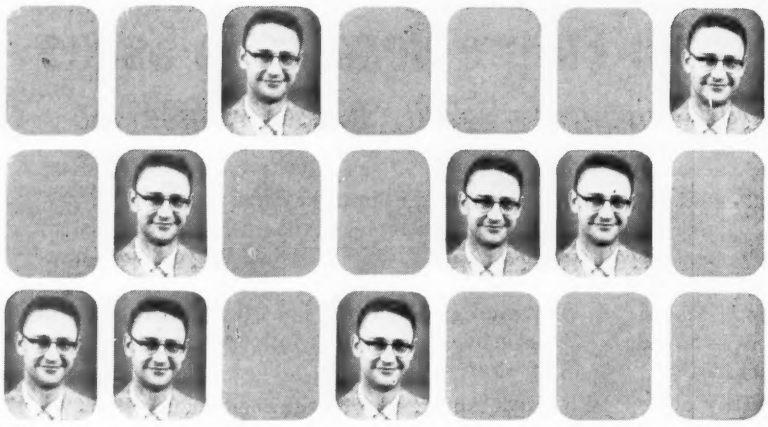

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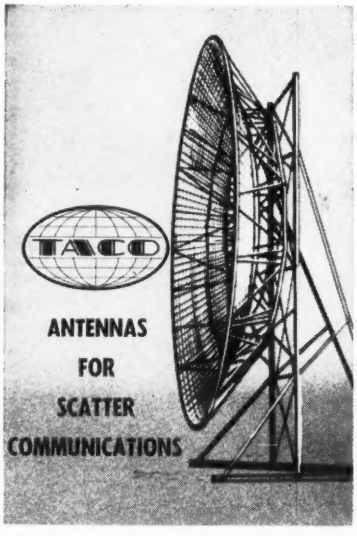

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Underwater Propulsion

(CONTINUED FROM PAGE 51)

underwater propulsion should be similar to those of high-speed aircraft or rockets.

The third reason for using jet propulsion is the ducting of the propulsion stream, which permits the use of this stream for the reduction of the drag of the propelled body.

On the basis of the foregoing considerations it is clear that the general technical field to be covered by the ARS Underwater Propulsion Committee will be underwater jet propulsion and its applications. This general field involves the following specific areas: Energy sources, powerplant and thrust producers, drag and its relation to propulsion, application of underwater jet propulsion to military missions and to transport, and systems considerations on underwater propulsion and vehicles.

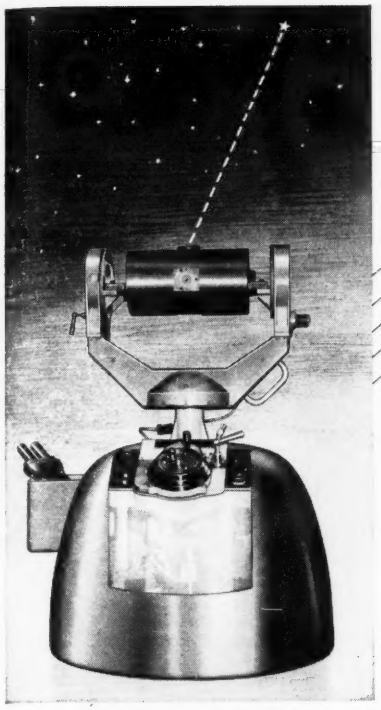
Energy sources to be considered are obviously those not dependent on the availability of atmospheric air. The resemblance of this requirement to the conditions applying to space propulsion and powerplants is rather striking, except for the availability of solar energy in the latter field. The energy sources are obviously either nuclear or chemical, including aspects concerning the direct conversion of these energies into electric power.

Powerplants and thrust producers are named together, as they are not separable in cases resembling rocket propulsion. Underwater rockets, which should be given first consideration, are likely to be used mostly in connection with some form of "augmentation." In addition, it is expected that some propulsion devices, corresponding to the aerial ramjet, pulsejet, turbojet, or turbofan will occupy important places in the activities sponsored by this Committee. Nuclear powerplants must receive extensive consideration as far as their problems are peculiar to underwater propulsion.

Drag considerations will apply primarily to the relationship between friction or form drag and the flow induced by the propulsion plant. A prominent example of this is boundary-layer control by means of the propulsion stream, which should be more promising for buoyant bodies than for airplanes, since for the former, skin friction and form drag constitute the total drag of the body.

Applications to undersea warfare are at present practically the only applications made of underwater propulsion. However, the potential value of submerged bodies for overseas transport is beginning to be recognized.

Systems considerations, particularly



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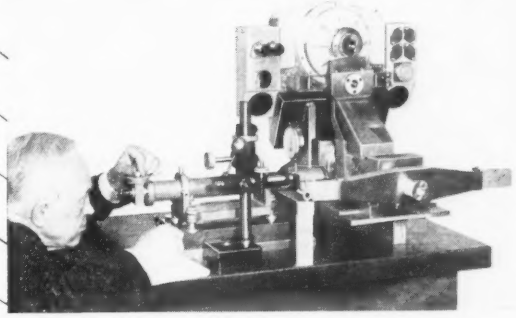

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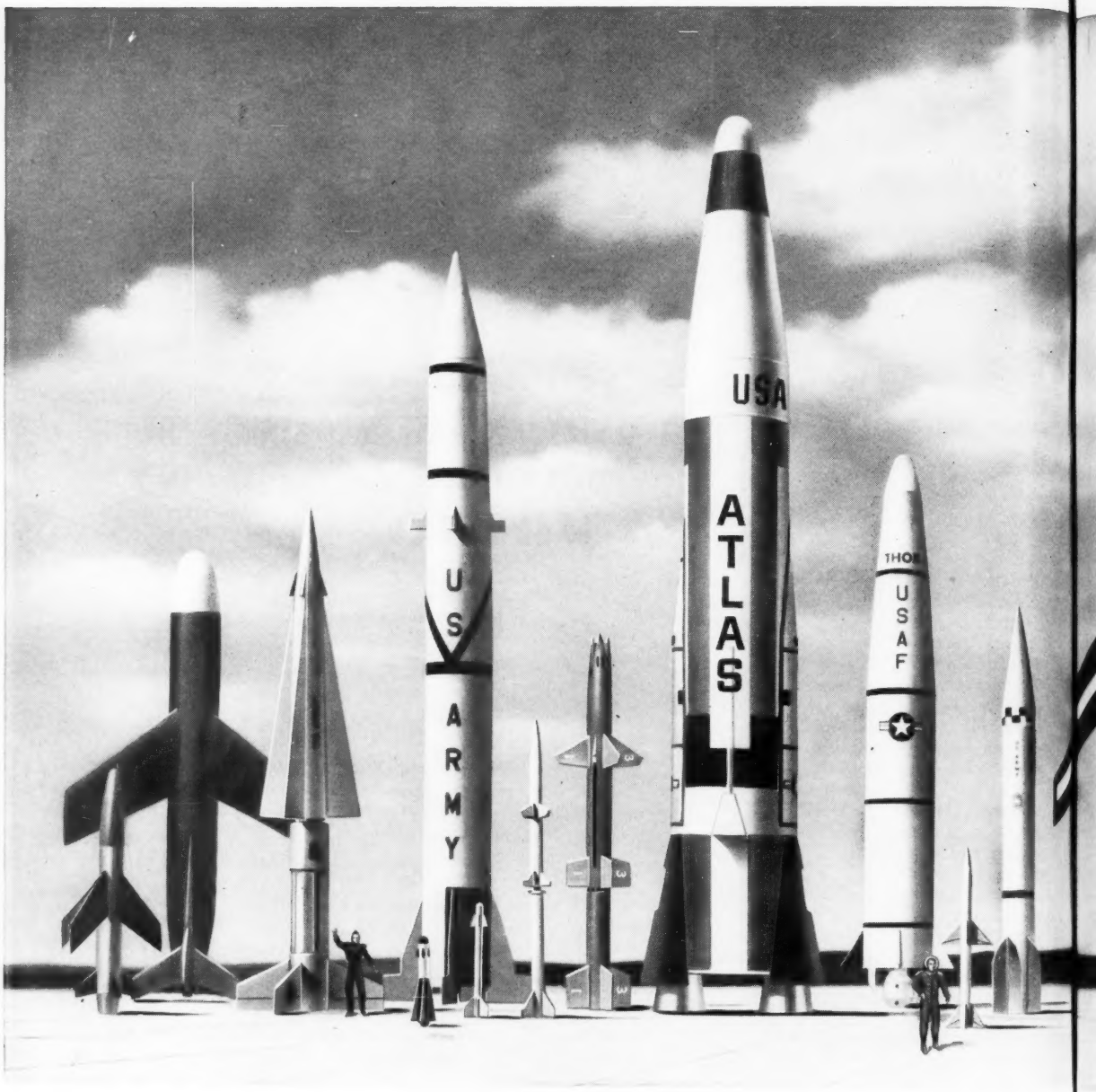

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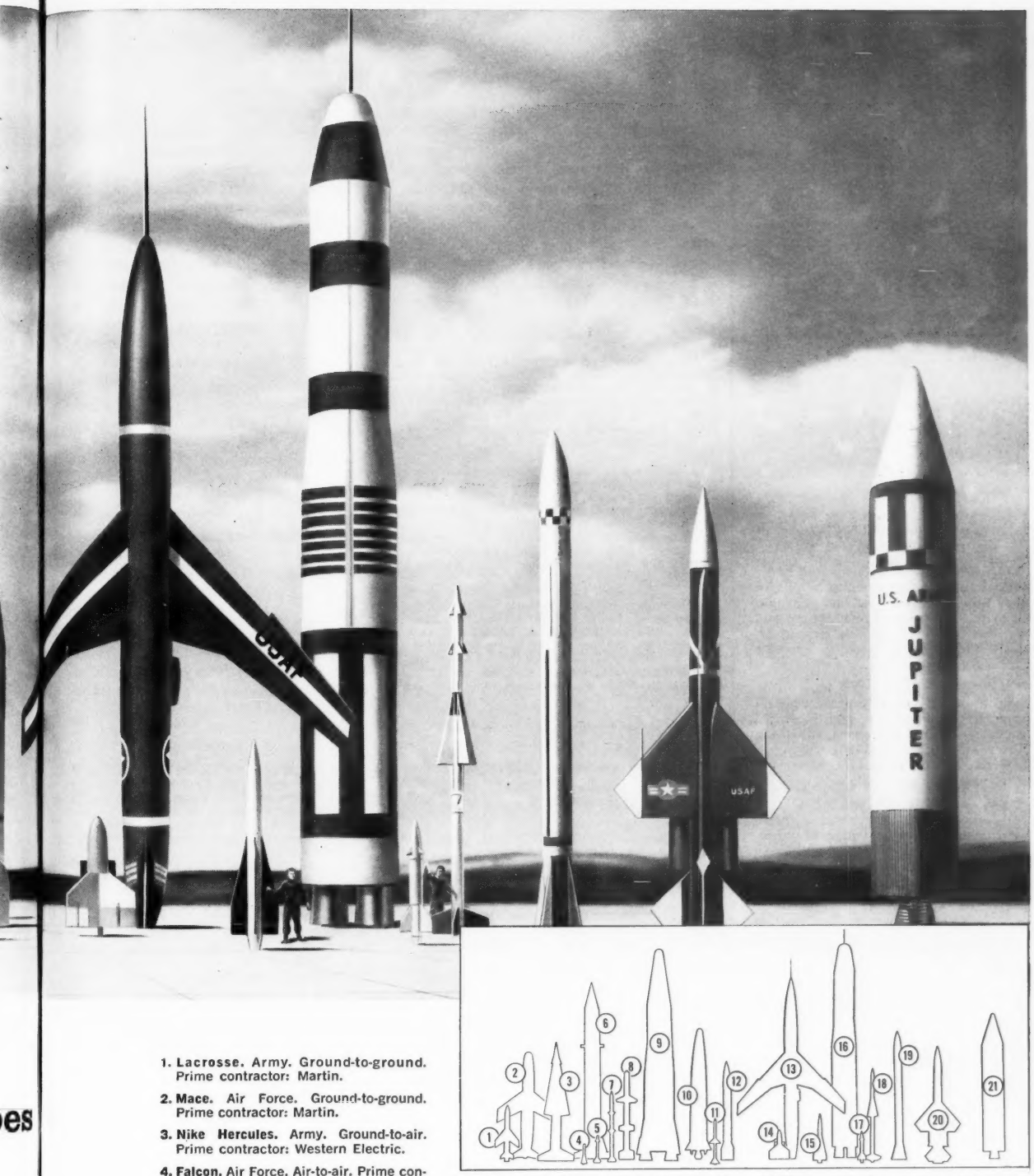

1. **Lacrosse.** Army. Ground-to-ground. Prime contractor: Martin.
2. **Mace.** Air Force. Ground-to-ground. Prime contractor: Martin.
3. **Nike Hercules.** Army. Ground-to-air. Prime contractor: Western Electric.
4. **Falcon.** Air Force. Air-to-air. Prime contractor: Hughes.
5. **Sidewinder (GAR-8).** Navy/Air Force. Air-to-air. Prime contractors: Philco; General Electric.
6. **Redstone.** Army. Ground-to-ground. Prime contractor: Chrysler Corp.
7. **Terrier.** Navy. Surface-to-air. Prime contractor: Convair.
8. **Talos.** Navy. Surface-to-air. Prime contractor: Bendix Aviation.
9. **Atlas.** Air Force. Ground-to-ground. Prime contractor: Convair.
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11. **Sparrow III.** Navy. Air-to-air. Prime contractor: Raytheon.
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14. **Quail.** Air Force. Air-to-ground. Prime contractor: McDonnell.
15. **Hawk.** Army. Ground-to-air. Prime contractor: Raytheon.
16. **Titan.** Air Force. Ground-to-ground. Prime contractor: Martin.
17. **Bullpup.** Navy. Air-to-ground. Prime contractor: Martin.
18. **Nike Ajax.** Army. Ground-to-air. Prime contractor: Western Electric.
19. **Corporal.** Army. Ground-to-ground. Prime contractors: Firestone; Gilfillan.
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similarity considerations on the hydrodynamic *and* mechanical problems involved, may become decisive for establishing the most promising trends for future developments.[4-5]

These areas of technical interest would be quite insufficient for the stimulation of lasting progress if their consideration were not based firmly on the basic sciences underlying this field. Yet the totality of these sciences is so broad as to require careful selection of the scientific subjects in relation to the field of underwater propulsion. The process of this selection might be taken as the state of the art.

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Structures and Materials

(CONTINUED FROM PAGE 49)

designed. Extensive use of sandwich construction and welding is particularly noteworthy in the development of the "hot" structures for the B-70.

The Department of Defense titanium-sheet rolling program has as its target the production of heat-treatable, high-strength titanium alloy sheet of uniform quality that can be formed in the solution-heat-treated condition and subsequently aged. As this program nears completion, it appears that the ultimate tensile strength target of 180,000 psi will be exceeded. Quantities of the various alloys are currently under evaluation by all of the major airframe producers.

Progress in the development of beryllium sheet and extrusions has been significant during the past year. These developments mark the maturing of this material for eventual structural applications. Indeed, the successful forging of beryllium heat sinks for the Mercury capsule is particularly noteworthy.

A major problem area that has clearly emerged during the past year is concerned with the use of high-strength, limited-ductility materials in structures. In the development of high-strength titanium and steel solid-propellant-rocket engine cases, meticulous care in design and fabrication are required to realize the strength potential of these materials. Their limited ductility cannot accommodate any significant stress concentrations introduced in design or fabrication.

It appears that the use of limited ductility and brittle materials is a facet of the hypersonic age with which structures people must learn to live. Beryllium, the refractory metals, and nonmetallic materials such as ceramics and graphite are all characterized by lack of the ductility commonly associated with aluminum alloys. The intolerance of hypersonic materials to stress concentrations will require great attention in design and fabrication.

A major trend which is apparent in all of these advances is the necessity for integration of structures and materials problems in design. This is a trend which has been recognized by ARS through formation of the Structures and Materials Committee during the past year. The trend has been apparent to individuals in government, industry, and universities. It appears that a new pattern of research and education will emerge which recognizes the tremendous advances to be gained from integration of structures and materials at a fundamental level.

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"Coatings for Protecting Molybdenum from Oxidation at Elevated Temperature," Report 109.

"Department of Defense Titanium Sheet Rolling Program," Report 46.

"Physical and Mechanical Properties of Nine Commercial Precipitation-Hardenable Stainless Steels," Report 112.

"Properties of Certain Cold-Rolled Austenitic Stainless Sheet Steels," Report 113.

"The All-Beta Titanium Alloy (Ti-13V-11 Cr-3 Al)," Report 110. ◆◆

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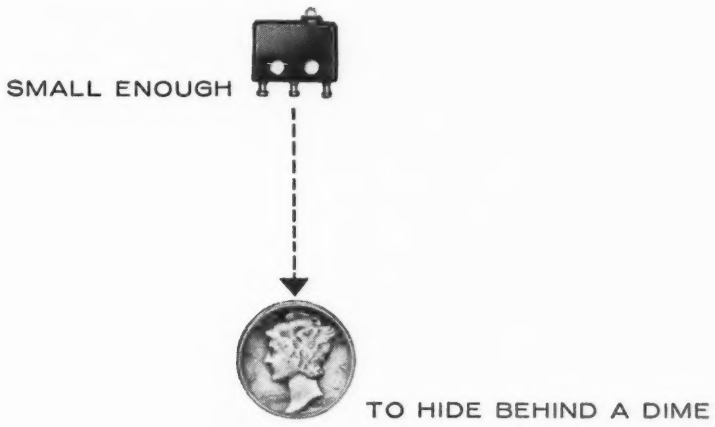

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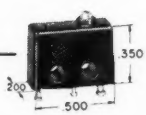

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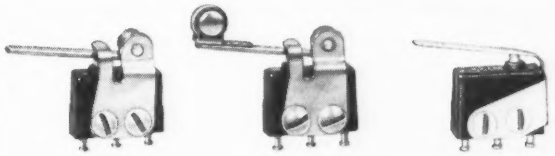

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American Bosch Arma has received AF contracts totaling $53,350,000 for advanced lightweight versions of all-inertial guidance systems for the operational Atlas, as well as additional systems and associated ground support equipment.

Data-Control Systems Wins Minuteman Telemetry Contract

Data-Control Systems was selected from among eight competing firms for an approximately $750,000 subcontract from Boeing Airplane to develop the FM/FM ground station telemetry system for the Minuteman test program.

Hawk Contracts to Raytheon

New contracts totaling $30,162,502 for Hawk ground support equipment and supplemental engineering services have been awarded by the Boston Ordnance District to Raytheon.

High-Energy Fuels Research

National Research Corp. has received a classified DOD R&D contract on high-energy solid-propellant missile fuels amounting to $150,000 on a cost-plus-fixed-fee basis.

Re-Entry Study

ABMA has awarded Polytechnic Institute of Brooklyn a $70,000 contract to support research on the re-entry characteristics of various types of space vehicles and satellites, including studies of feasible shapes of spaceships and satellites.

Small Rocket Lift Devices

Aerojet-General has received an Army contract for a feasibility study of small rocket lift devices to power combat troops to enable them to overcome terrain obstacles.

AFOSR Basic Research Awards

The AF Office of Scientific Research has awarded basic research contracts for a one-year period to:

Avco Research Lab ($585,000) to investigate magnetofluiddynamic forces and other phenomena with respect to problems of propulsion in cislunar space; RCA, Princeton, N.J. ($140,000), to study acceleration of plasma by an alternating nonuniform field to obtain very high specific im-

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Acoustica Associates	$ 90,000	Investigate use of sound waves to control burning rate of solid rockets.
Aerojet-General	$ 90,000	Study operation of small turbopump which might be used in a nuclear rocket engine.
AFBMD	$2,500,000	Incremental funding for 10 Atlas boosters for mercury test and orbital flights.
	$ 280,000	Installation of special radio acquisition equipment at Kaena Point, Hawaii, tracking station for use in communications with Tiros, and for operational costs of station for three months.
	$ 130,000	Operation of computers and postflight analysis of data on coming launchings of Delta.
AF ARDC	$3,200,000	Funding for liquid hydrogen second stage of Centaur.
AOMC	$1,300,000	Incremental funding for eight Redstone boosters for Mercury suborbital flight tests.
	$ 650,000	Incremental funding for five Juno II boosters.
	$ 300,000	For completion of lunar project studies.
	$ 150,000	Instrumentation to duplicate 91-lb satellite payload which failed to orbit July 16, 1959.
	$ 100,000	Funds for Project Beacon payload which failed to orbit Aug. 14, 1959.
JPL	$3,400,000	Incremental funding for technical project supervision, deep-space mission planning, and third stage of Vega.
	$ 250,000	Various research programs.
Lockheed Aircraft	$ 50,000	Studies of solid rocket configurations and payload capabilities.
MIT	$ 200,000	Incremental funding for assistance in evaluating Project Mercury tracking facilities and ground instrumentation.
McDonnell Aircraft	$3,000,000	Incremental funding for 12 Project Mercury capsules.
Mine Safety Appliance Research	$ 70,000	Evaluate use of two superoxide compounds (KO_2 and NaO_2) as oxygen suppliers for extended manned spaceflights.
Minneapolis-Honeywell	$ 70,000	System of flight control jets for Little Joe capsule models.
NBS	$ 70,000	Research into boundary layer transition.
NRL	$2,500,000	Drawing account for elements of NASA's Goddard Space Flight Development Center.
North American Aviation	$ 100,000	Incremental funding for 6 Little Joe boosters.
Purdue Univ.	$ 200,000	Three-year grant for study of mathematics of rocket and space vehicle guidance and control.
Stanford Univ.	$ 90,000	Continuing studies of satellite radio signals in an effort to learn more about make-up of ionosphere.
Univ. of Illinois	$ 60,000	Continuing studies of satellite radio signals in an effort to learn more about make-up of ionosphere.
U.S. Weather Bureau	$ 50,000	Meteorological analysis during 1960.

GENERAL ELECTRIC

ANNOUNCES

the establishment of the

Special Programs Section

of the

DEFENSE SYSTEMS DEPARTMENT

(A Department of the Defense Electronics Division)

. . . to serve the needs of

THE UNITED STATES ARMY

in the areas of

SYSTEMS ENGINEERING and MANAGEMENT

- *MISSILE SYSTEMS*
- *INTELLIGENCE SYSTEMS*
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A few senior positions exist for individuals with experience in missile and electronics systems engineering. We would welcome the opportunity to review your resume, sent to:

Dr. W. Raithel
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General Electric Company
21 South 12th Street
Philadelphia, Pennsylvania*

*Temporary location while new facility is being constructed in suburban Radnor, Pennsylvania.

GENERAL ELECTRIC

TOP SPOTS FOR A TECHNICAL SPECIALIST AND TECHNICAL LEADER ON A NEW SPACE TEAM

Two excellent openings in Chance Vought's newly formed Astronautics Division.

Senior Specialist in Heat Transfer and Fluid Mechanics.

Advanced A.E., Ph.D. preferred. To supervise group in fields of heat transfer, pressure distribution analysis, ablation theory and general fluid mechanics. Requires knowledge of real gas effects, capability for training people, supervising company R & D, keeping abreast of technology.

***Physics M.S. with Minor in Meteorology* (and meteorological experience).**

To study physics of upper atmosphere, including compilation of data. Interpret data on atmospheric density, pressure, temperature and composition. Keep abreast of space probe and satellite data. Plan test programs.

Recommend experimental work and conduct feasibility studies for weather satellite programs.

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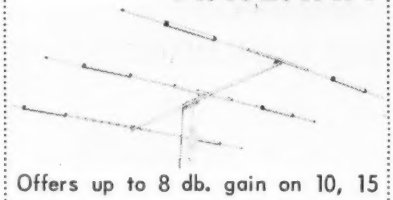

Offers up to 8 db. gain on 10, 15 and 20 mcs. to provide better reception of WWV and WWVH. 20 db. front-to-back signal ratio minimizes interference at locations between these two stations. Model WWV-33 Antenna is 100% rust-proof, built to withstand 150 mph winds. Easily assembled and installed by non-technical personnel.

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BRIDGETON, MISSOURI

WRITE FOR INFORMATION

pulses in rocket motors; J. A. Hynek, Smithsonian Astrophysical Lab ($50,000), to conduct high-altitude astronomical research using stabilized telescopic platforms supported by manned balloons at 50,000 ft alt.; Dr. S. J. Kline, Stanford Univ. ($44,358), to continue study of fluid dynamic problems in diffusers and ducts, particularly boundary-layer stability in internal flow systems; Univ. of California ($58,000), to establish the tolerance and adaptability of the human brain to spaceflight environment, and ($40,000) to do research in adaptive control systems theory; and to Washington Univ. ($350,000) to continue studies of nuclear propulsion and interactions in the medium-energy range.

Test Requirement

Allen B. Du Mont Laboratories, Inc., will study and evaluate test requirements for future AS and AA missiles and target drones under a $450,000 Navy BuAer contract.

Solar Power for Satellites

A $600,000 contract for development of a large area solar-electric power system for use in space satellites has been awarded to Hoffman Labs Div. of Hoffman Electronics by WADC.

High-Speed Core Memory

Telemeter Magnetics, Inc., has received a $200,000 ONR contract for a core memory having a capacity in excess of 850,000 bits for use with the Naval Research Electronic Computer (NAREC).

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formally advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army, and Navy contracting office:

AIR FORCE

AF Cambridge Research Center, Laurence G. Hanscom Field, Bedford, Mass.

Design and development of television system for detecting and tracking artificial earth satellites, $71,243, **Bendix Aviation Corp.,** Research Laboratories Div., P.O. Box 5115, Detroit, Mich.

Design and fabrication of lightweight balloon-borne parachutes, $27,771, **Pioneer Parachute Co., Inc.,** 168 Forest St., Manchester, Conn.

Satellite tracking camera, Baker-Nunn-Schmidt Type, $182,000, **Joseph Nunn & Associates,** 916 Meridian Ave., South Pasadena, Calif.

AF Office of Scientific Research, Washington 25, D.C.

Research in fluid dynamics, $41,690, **MIT,** Cambridge 39, Mass.

Continuation of research in gaseous electronics, $30,700, **Univ. of Minn.,** Minneapolis 14, Minn.

Continuation of research on Nuclear Emulsion Studies of Antiprotons, Strange Particles, and K Meson Interactions, $25,997, **Univ. of Miami,** Coral Gables 46, Fla.

ARMY

Army Ordnance Dist., Los Angeles, 55 S. Grand Ave., Pasadena, Calif.

Hypersonic research, $40,000, **CalTech,** 1201 E. California St., Pasadena, Calif.

Design and development, $33,000, **North American Aviation,** 6633 Canoga Ave., Canoga Park, Calif.

Loading and testing of motors, $159,351, **Cooper Development Co.,** 2626 S. Peck Road, Monrovia, Calif.

Testers, $53,153, **Telecomputing Corp.,** 12838 Saticoy St., N. Hollywood, Calif.

Study and design of infrared decoy system, $147,622, **Hughes Aircraft,** Culver City, Calif.

Study of an infrared decoy system, $149,378, **Aeronutronics,** a Div. of Ford Motor Co., Ford Road, Newport Beach, Calif.

Sergeant missile, $277,460, **Sperry Rand Corp.,** Sperry Utah Engineering Laboratory Div., 322 N. 21st West, Salt Lake City, Utah.

N.Y. Ordnance Dist., 770 Broadway, New York 3, N.Y.

Design and development of ten inertial devices, $157,520, **Ford Instrument Co.,** Div. of Sperry Rand Corp., 31-10 Thomson Ave., Long Island City 1, N.Y.

Army Signal Supply Agency, 225 S. Eighteenth St., Philadelphia 3, Pa.

Satellite communications study, $225,871, **General Electric,** Utica, N.Y.

NAVY

Office of Naval Research, Washington 25, D.C.

Research in connection with fleet ballistic missile program, $49,923, **Vitro Laboratories,** Div. of Vitro Corp. of America, Silver Spring, Md.

Research in connection with Tartar weapons system, $42,411, **Dunlap & Associates,** Stamford, Conn.

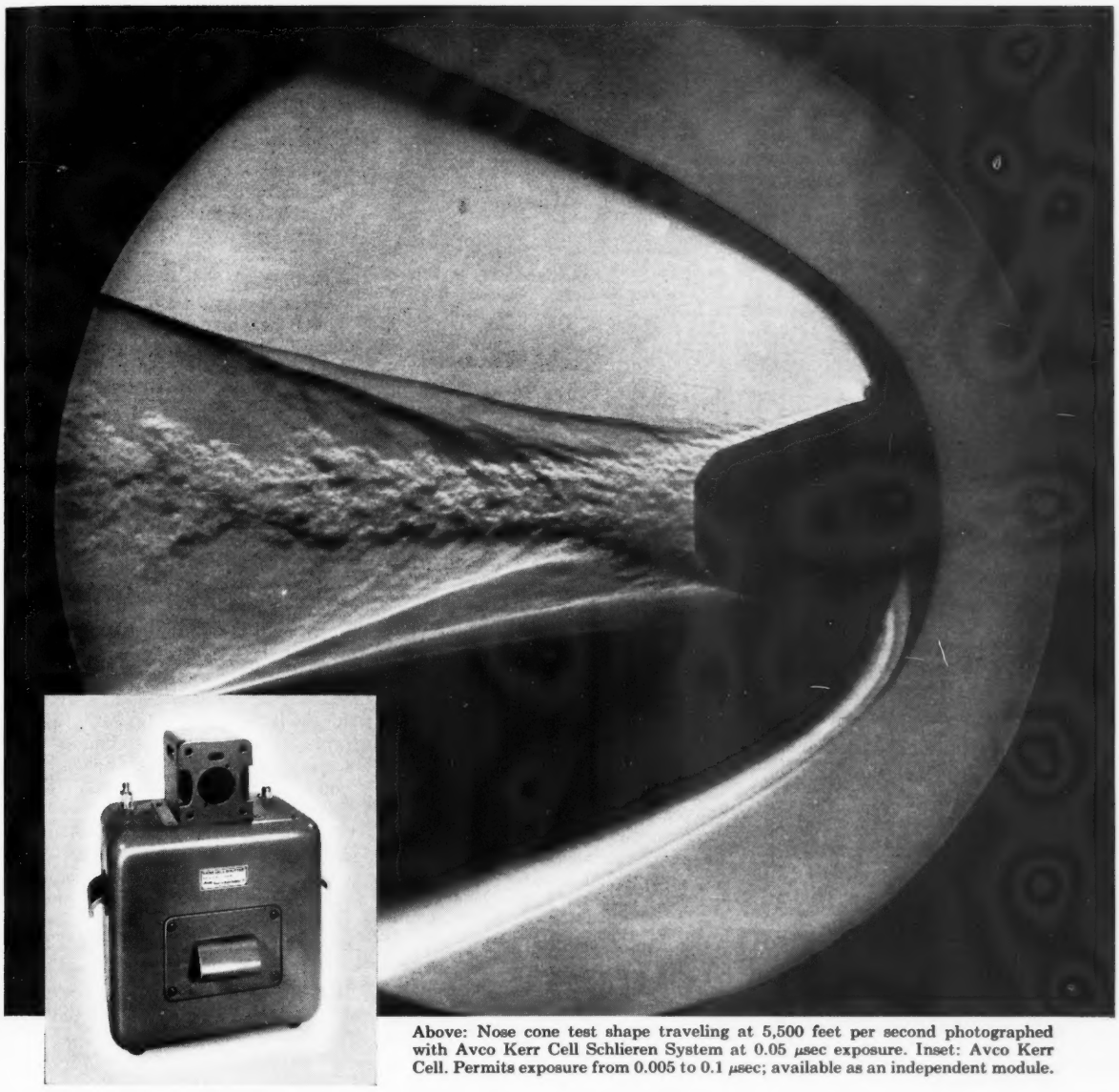
Studies on arc plasma, $44,490, **Purdue Research Foundation,** Lafayette, Ind.

Research in high energy physics, $107,000, **Syracuse Univ.,** Syracuse, N.Y.

Naval Research Laboratory, Washington 25, D.C.

Digital computer (with associated components), $76,175, **Bendix Computer Div.,** Bendix Aviation Corp., 5630 Arbor Vitae St., Los Angeles, Calif.

Seven track record reproduce magnetic recording system, $114,357, Mincom Div., **Minnesota Mining and Mfg. Co.,** 2049 S. Barrington Ave., Los Angeles 25, Calif.



Above: Nose cone test shape traveling at 5,500 feet per second photographed with Avco Kerr Cell Schlieren System at 0.05 μsec exposure. Inset: Avco Kerr Cell. Permits exposure from 0.005 to 0.1 μsec; available as an independent module.

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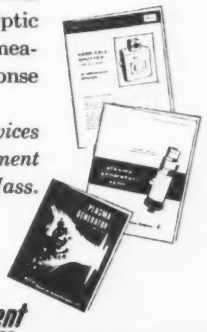
USE-PROVEN INSTRUMENTATION FOR HYPERVELOCITY RESEARCH

Capture submicrosecond events with Avco's new instrumentation. Kerr Cell Shutters for exposures from 0.005 to 0.1 μsec; Rotating Mirror Cameras for streak photography with writing rates up to 4mm per μsec; Rotating Drum Cameras for streak, spectographic and Schlieren photography with writing rates up to 0.19 mm per μsecond; general-purpose Package Light Sources with light durations from 0.3 to 1.0 μsec at various energy levels; complete Kerr Cell Shadowgraph and Schlieren photograph systems; Auto-Optic Recording Pyrometers for temperature measurements up to 3,000° C. with response times better than one millisecond.

For bulletins, write: Products and Services Dept., Research and Advanced Development Division, Avco Corporation, Wilmington, Mass.



AVCO
Research & Advanced Development division

SEE LIVE DEMONSTRATION OF AVCO SHADOWGRAPH — BOOTH 202 AT ARS ANNUAL MEETING

TV for Rockets

Scientists at Lockheed Missiles and Space Div. recently unveiled a 9-lb battery powered television system that will transmit a high quality picture 1000 miles. Made especially rugged for use in missiles and space vehicles, the TV system is shown in the photo foreground transmitting from a vibration table in motion. It will withstand 50-g acceleration and 40-g shock.

Missile Market

(CONTINUED FROM PAGE 106)

itary, and corporate and individual owners. Air Cruiser Co. turns out life rafts, vests, and other survival equipment; shielding materials for nuclear equipment; and rubberized fabric products for aircraft and industry.

Within this comprehensive product line, several items stand out. AiResearch's (Los Angeles) air data computing system already is performing in the McDonnell F4H and the North American A3J Vigilante. This division won recently the contract to supply central air data computing systems for the B-70.

In the fields of electronics, heat transfer, turbomachinery, pneumatics, hydraulics, and valves, AiResearch's products are expanding their missile role. The company's turbine auxiliary power unit, which provides all hydraulic power for internal operation of the Army's Nike-Hercules, is the largest missile production item. Increasing quantities of pneumatic controls and valves are being supplied to the Atlas and Titan programs. Other missiles using AiResearch products are Polaris, Subroc, Green Quail, Jupiter, Thor, Sergeant, Snark, and Matador. For the nation's two leading spaceflight programs sponsored by NASA—X-15 and Project Mercury—AiResearch has been called upon to provide the air-conditioning and pressurization systems.

Maintaining its leadership in aircraft pressurization and air-conditioning systems, the company has been installing equipment in the Boeing 707, Lockheed Electra, and France's Caravelle, as well as in many other new commercial and corporate and military aircraft.

AiResearch's gas turbine starting engines—the little jets that start big jets—also are worthy of mention. With hundreds on duty at AF bases around the world, they have become a sizeable commercial item with even more promising potential as the airlines have thrust into the Jet Age.

Commercial and military aviation products thus provide the company's biggest volume of sales. The dollar volume of aircraft procurement has been far greater than for missiles, although the growth rate of missile procurement has far outstripped aircraft. Recognizing this, management believes Garrett's new products—such as central air data systems, fuel heaters, and gas turbine auxiliary power units—should largely offset, in the next five years, the declining dollar value of military procurement. Meantime, commercial business grows in importance, contributing 26 per cent of sales in fiscal 1959, the fifth successive year it has moved higher.

Garrett should be able to sustain the sales growth that set a record of $193.6 million in the last fiscal year, up 14 per cent from the year before. With gains of 9 per cent in military sales and 31 per cent for combined foreign and commercial sales, prospects favor another sales record this year. To provide for this growth, plans are well underway for expansion of manufacturing facilities on a new 66 acre site at Torrance, Calif.

Earnings of $4.61 per share were reported last year, compared with $3.98 the year before. This column estimates that earnings will exceed $5.00 per share in the current fiscal year.

Garrett's 1,033,953 shares of common stock are listed on the N.Y. Stock Exchange, and are preceded by $12,321,428 of long-term debt. The major portion of this debt is represented by $10,000,000 of convertible subordinated debentures, which are convertible into common stock at $44.66 per share on or before September 15, 1968. These debentures also are listed on the N.Y. Stock Exchange.

Logistics and Operations

(CONTINUED FROM PAGE 39)

must be sustained in a space station, a space ferry, or an interplanetary flight.

Space-vehicle operations this past year have increased in number, complexity, and results. Most of these operations involved the launching of orbiting satellites. In addition, one successful U.S. space probe is now cruising our solar system. Vehicles for the launching of satellites into polar orbits, previously unattainable from Cape Canaveral, are now being launched from Vandenberg Air Force Base.

Admittedly incomplete, this report will, it is hoped, notify those concerned with logistics and operations that there is a channel for future report material. The writer will welcome such material, especially if it includes citation of published information for a bibliography. Any amplification, clarification, or opinion on this report, and guidance toward future annual reports, will also be welcome.

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Operations

R&D testing is almost entirely classified and many reports are even further restricted because of claims of "proprietary" information. ASTIA (Armed Services Technical Information Agency) makes many of these available in abstract and microfilm form. ◆◆

A Service Message from MAGNAFLUX

"Just a Little Old Crack"

A crack too small to be seen even with a microscope can stop a countdown —or a missile in flight—or cause failure of ground handling or servicing equipment.

Yet out of a vast accumulated experience, metallurgists now generally agree that cracks or similar defects open to the surface or immediately beneath it are the cause of most localized high stresses and failures of parts under high loads.

Most of them also believe—and put into practice—the fact that preventing failures is very often just a matter of finding cracks . . . that there are many test systems available . . . but that no single test is best for *all* needs.

Only the most careful evaluation—impartially undertaken—permits each test system to be used to its fullest potential.

We suggest that in the missiles and spacecraft program such an evaluation can help to achieve faster production schedules, more effective testing and more "right starts" in design development.

In this race the penalties of failure may be enormous. To you we pledge our fullest cooperation, and will welcome yours.

Meanwhile, in your preliminary thinking, the following listing may be helpful, showing some of the test systems available to you.

X-Ray

One of the most valuable tools, especially for finding sub-surface defects. May be used on practically any material. Permits permanent records for future reference or immediate interpretation. Is relatively slow. May not always find cracks or leaks.

Magnetic Particle

Uses controlled magnetic leakage fields to find all cracks, porosity or other defects at the surface or reasonably close to it. By far the most common crack-finder for magnetic metals used in critical service. Will find some defects in weldments that X-ray may overlook. Marks defects right on the part. Simple procedures enable permanent records. Black light and fluorescent materials speed up testing. May not find very deep seated defects, and requires knowledge of many ways and means of magnetizing complex shapes.

Fluorescent Penetrant

Most sensitive method, uses capillarity to find cracks and other defects open to the surface in nonmagnetic metals, and most other solid, nonporous materials. Recent developments have increased sensitivity—will now find some defects no other method will detect. Readily tests complex shapes or high volumes. Offers near-absolute reliability in leak tests. Special formulae may be used safely on LOX systems. Speed governed only by requirements, but reliable results require engineered test set-up and control.

Dye Penetrant

Dependable test on moderately "clean" or medium to large size defects (which may still be invisible). Original cost very low. May be fully portable, in spray can kits. Can be used on any metal, most other materials. Less sensitive than fluorescent penetrant tests.

Ultrasonic Testing, Resonant

Especially useful for determining thickness measurements from one side only—or finding lack of bond in laminates. Available in both oscilliscope and portable direct reading instruments.

Eddy Current Testing

Developed by Institute Dr. Foerster, Germany, for nondestructive testing. Evaluates effect of conductive materials on eddy currents induced within them. New uses are being found almost daily. Many properties and defects can be evaluated, including hardness, conductivity, alloy composition, chemical purity, cracks, heat treatment conditions or heat affected zones. Instruments for testing magnetic or nonmagnetic metals. Operation may be automated, when desired.

Brittle Coating Stress Analysis

Determines stress concentration and measures values in simple or complex shapes, in static or dynamic testing, and over the entire part. Parts can be immersed in oil or tested at temperatures to 600° F. with newest coatings.

Magnaflux Corporation engineers and manufactures most of the nondesructive test systems mentioned here. These —and numerous others—are available to you through Magnaflux. Our experience is at your disposal—through Magnaflux Nondestructive Testing Engineers who are recognized consultants in their fields, or through technical literature and reports. Write us your questions—or tell us your needs. If we haven't the answer, we'll try to find it for you or will refer you to others who have the answer.

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Magnetic Particle Testing

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Dye Penetrant Testing

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SONIZON
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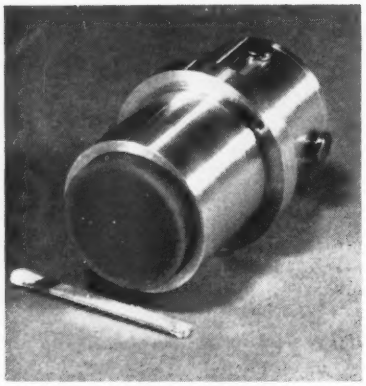
STRESSCOAT
Brittle Coating Stress Analysis

Also Other Test Systems for Most Materials

Commercial and Field Inspection Service, including all Magnaflux Corporation Test Systems, and several others.

VISIT US IN BOOTH 103 ARS NATIONAL ASTRONAUTICAL EXPOSITION

Solid-State Radiation Tracking Transducer



A highly adaptable solid-state radiation tracking transducer that detects the position of visible to near-infrared light sources is now available from Electro-Optical Systems, Inc., 170 N. Daisy Ave., Pasadena, Calif. A single-element, linear function, semiconductor device, it can detect the position from which a light or heat source is radiating, and is applicable to tracking, instrumentation, automation control, and computer technique.

Highly sensitive, the RTT possesses microsecond response characteristics. The detection process occurs by means of a lateral photo-effect in a silicon p-n junction. The wide angle scope, minute size, and self-generating power capabilities of the unit add to its extensive scope of applications.

Human Factors

(CONTINUED FROM PAGE 34)

selection and training for spaceflight; and, finally, bio-instrumentation, which has undergone a revolution which will permit the measurement of man and man's performance under both actual and simulated flight conditions.

Studies of manned space vehicles to date have demonstrated the need for mustering all of the life-science resources of the U.S. into a team which will provide the best answers to flight problems before the actual flights get underway.

A related need has seen the birth of a new, close working relationship between human factors specialists and engineers. Here again, it has become obvious that the bio-scientist and the engineer must work hand in hand to meet the rigorous development schedules for booster hardware.

The ARS Committee on Human Factors and Bio-Astronautics, although pleased with progress in its field, believes that advances in hardware are already pushing the human factors people in such areas as future requirements for environmental control, crew relationships in confined quarters, and prolonged periods of exposure. Actually, the bio-scientist again appears to be falling behind the engineering program.

This is not to say that future program needs present insurmountable problems. It does suggest that a great effort must be made to produce more efficient and speedy methods of obtaining data which will permit the life-support areas to keep pace, with the national space program.

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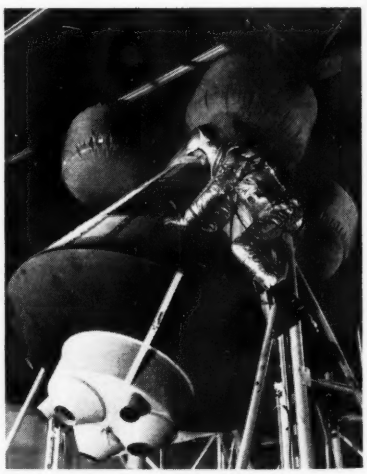
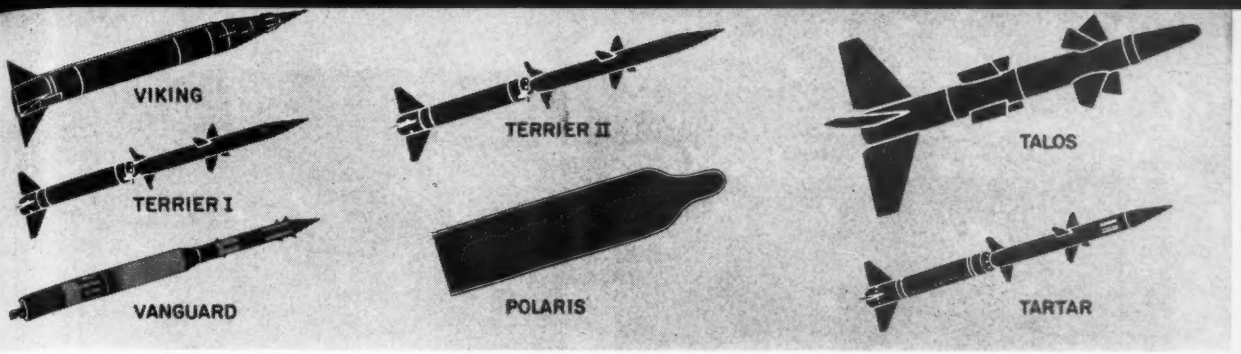
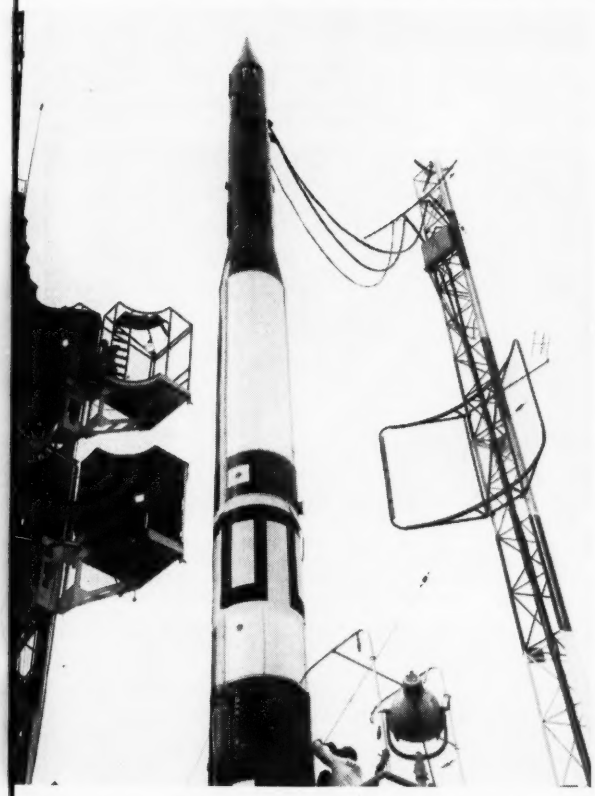
Mercury Capsule and Cargo



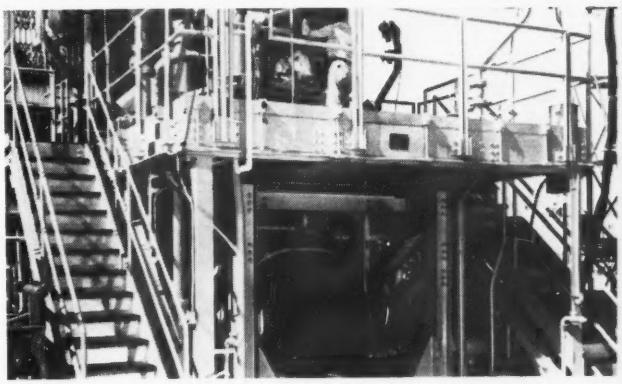
Pilot prepares to climb through entry hatch of Mercury capsule in this first view of the McDonnell mockup to be released publicly. Photo provides good view of retrorockets and flotation bags designed to give capsule buoyancy and stability in water.



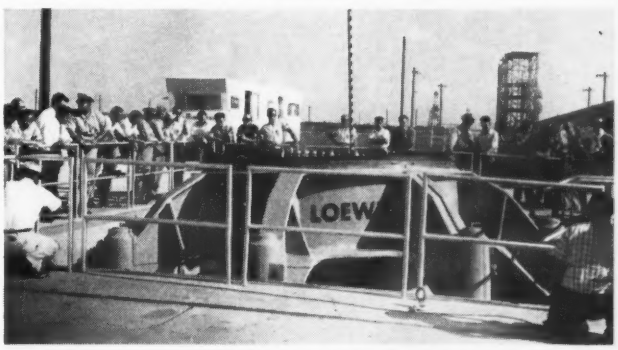
Loewy-Hydropress has been engaged in building handling, stowage and launching systems for these rockets and missiles.



Vanguard rocket being readied for launching on March 17, 1958.



Testing and firing installation for Viking and Vanguard rockets.



Ship motion simulator for test-firing U.S. Navy's guided missile "Polaris" under seagoing conditions.

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Giant and unusual facilities for handling, testing and launching missiles and rockets have been built and put in operation by Loewy-Hydropress for the U.S. Navy's Fleet Ballistic Program and for the joint IGY Program of the Navy and the National Academy of Science. These installations have proven their brilliant effectiveness under the most trying circumstances.

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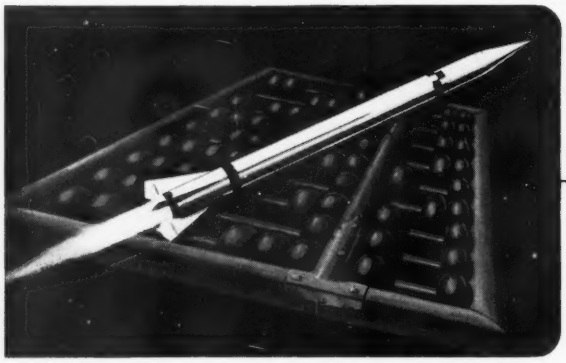
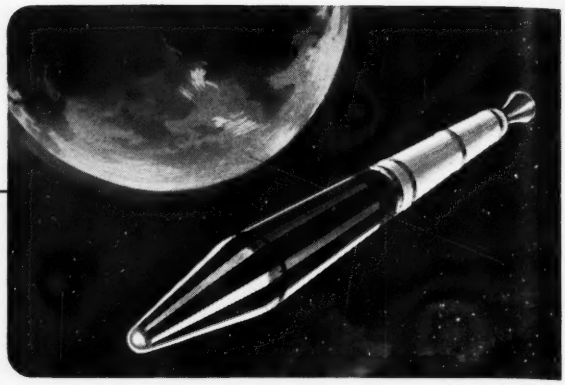
GUIDANCE RESEARCH . . . by JPL has led and advanced the field of missile guidance. Among these achievements are the application of Wiener RMS methods to multiple-input, multiple-loop servos, and matching missile trajectory to missile control transfer function for optimum accuracy.

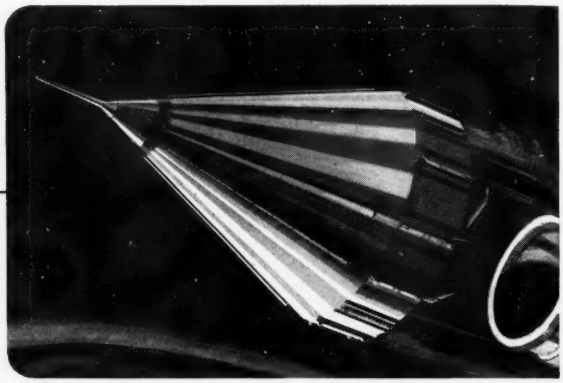
GUIDANCE SYSTEMS . . . both inertial and radio-command types employing new concepts of radar communication have been pioneered at JPL. This guidance system development activity is supported by basic research in all phases of electronics.



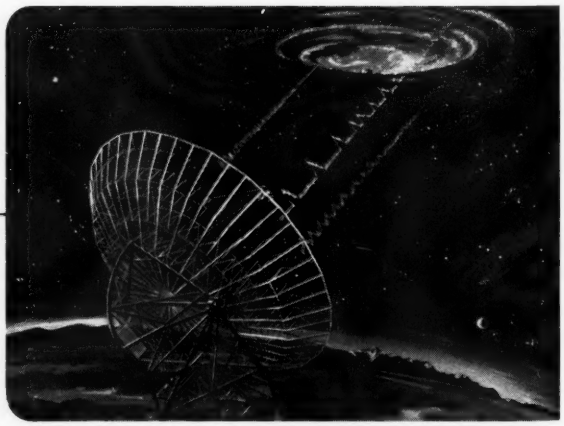
COMPUTERS . . . and the application of computing techniques to missile guidance systems have been pioneered by JPL. The Laboratory is now searching for new techniques that will further advance the state of the art in digital guidance components and computer systems.



DATA TRANSMISSION . . . brings news from space via the Explorer series. Explorer III used a tape recorder the size of a cigarette pack capable of transmitting two hours of information in 5 seconds. Electronic payload weight was approximately 11 lbs.



INSTRUMENTATION . . . of the moon probe provided measurement of radiation environment at distances far from the earth. Telemetered data revealed the existence of high intensity radiation. Miniaturization resulted in an instrument payload weighing only 10 lbs.



COMMUNICATIONS . . . pioneering in interplanetary communications resulted in this giant parabolic radio antenna, 85 feet in diameter, developed by the Laboratory which enables the tracking and reception of scientific data from great distances.

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Test Facilities

(CONTINUED FROM PAGE 50)

with these tests can be accommodated. Production, storage, and handling of the necessary working fluids has been achieved. Facilities to accommodate applied-research and development tests of ion propulsion are underway. The large electrical power requirements can be accommodated. While facilities themselves have yet to be constructed, the criteria have been fairly well defined.

Considerable facility effort and testing has been done on hardbase facilities. The requirements for isolation, shock mounting, and hardening have been ascertained in general. Silo configurations and transient conditions have been tested.

Considerable fabrication, construction, and operation have taken place on high-energy test facilities. Methods of properly handling the toxicity and other hazardous features of high-energy propellants have been demonstrated and are in operation.

Test facilities have recently been constructed for the conduct of extensive environmental simulation tests of all the various valves, regulators, etc., of missile and spacecraft systems. These facilities are capable of subjecting the component to the combined environment of constant acceleration, vibration, temperature extremes, humidity, and sand or salt spray. All these environmental conditions will be applied simultaneously while the component ducts propellant for which it is designed.

Unique Facilities

Several unique facilities have been developed recently to provide better simulation of the complete vehicle in actual flight conditions. Altitude simulation for rocket-engine firings has been accomplished with a pressure equivalent to 200,000 ft of altitude. The effect of low pressure on ignition, combustion, flame spreading, ionization, and vehicle base pressure has been investigated. Complete ballistic missile systems have been tested utilizing a soft mount to simulate freeflight vibration environment. These soft-mount facilities have up to six degrees of freedom and allow essentially undamped vibration down to about five cps. Also, facilities have been developed for subjecting a complete ballistic missile to simulated shipboard motion.

As to the future, in order to increase the rate of progress of propulsion system development, upon which all rocket or space systems are dependent, test facilities must be developed in which the state of the art of rocket propulsion can be improved. New kinds of facilities are required. In many cases a new system can be designed and fabricated before a facility can be obtained for testing the system.

It will be necessary to have additional tracking and data-receiving stations to permit a much greater variety of launching azimuths, including launches in an equatorial orbit. A problem still exists in dealing with toxicity and radioactivity at launch sites.

Many test-facility and ground-support-equipment problems associated with putting a man in a space vehicle have yet to be solved.

Improved reliability has been achieved on ground-support equipment, as demonstrated in the number of launchings achieved and the relatively few delays attributable to the support equipment.

New Insulators

Considerable improvements have been made in the insulation of cryogenic propellants. Previous materials were capable of containing liquid oxygen with a boiloff of approximately $^1/_2$ per cent per *day*. The new insulators will contain liquid oxygen with a boiloff of about 8 per cent per *year*. The recent establishment of a Cryogenic Data Center at the Cryogenic Engineering Laboratory, National Bureau of Standards, Boulder, Colo., is an important contribution to the advancement of cryogenic systems.

Considerable equipment has been developed for the handling of the new high-energy propellants. Handling of these formerly so-called exotic propellants is now almost akin to the handling of the old standbys such as nitric acid and liquid oxygen. It is now possible to ship liquid fluorine almost as readily as liquid oxygen. Advances have also been made in the storage and handling of liquid hydrogen. This has been brought about mainly as a result of the new National Bureau of Standards process for producing stable hydrogen. Previous methods produced unstable hydrogen, which released heat during conversion from unstable to stable hydrogen while in storage. This heat release caused considerable boiloff.

There remains, however, much work to be done on ground-support equipment. For instance:

Equipment will have to be developed for handling and servicing vehicles of up to 25 million lb of thrust.

The tremendous variety of ground support equipment has introduced some unnecessary duplication. It is necessary to standardize this equipment where possible to reduce the cost and complexity.

Better methods and equipment are required for quality control and contamination determination of propellants and related equipment.

Ground-support equipment has yet to be developed for use in launching a vehicle from a satellite or from the moon or planets.

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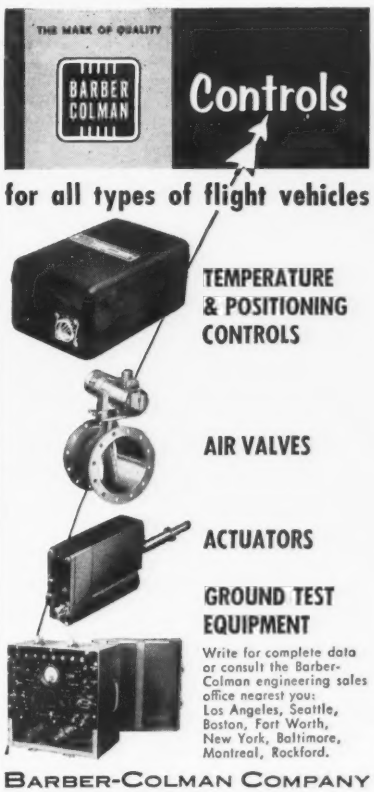
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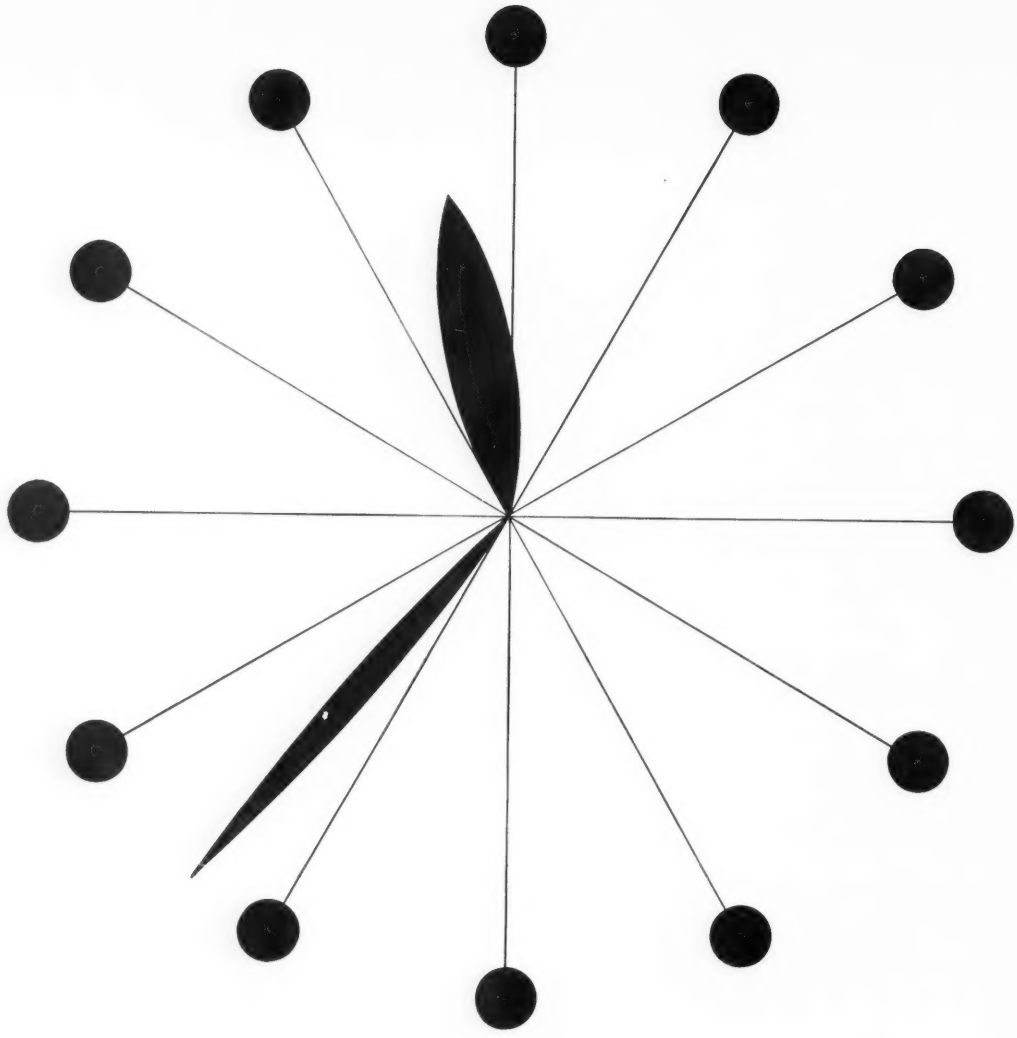

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Ramjets

(CONTINUED FROM PAGE 46)

ramjet potential are a recoverable space-vehicle booster, a low-level long-range attack aircraft, an extension of the Talos development and possibly Bomarc and the commercial transport. The Air Force recently announced that Project Pluto, the nuclear-ramjet study program that fits the second category, now has development status, and issued a large contract to Marquardt Aircraft for further component development. Associated test facilities have been built at the AEC's Nevada proving grounds. Though not so specific in intent, such things as the continued support of VTOL systems and possible mixed engine cycles; the building of hypersonic test facilities at Arnold Engineering Development Center, Marquardt, Cornell Univ. and elsewhere; and a possible breakthrough in the combustion of high-density solid fuels for ramjets—all point to a concerted effort to bring the other applications into being in the near future, especially as systems in the high-supersonic and low-hypersonic range.

Structures Emphasized

Because ramjets are increasingly sensitive to changes in component characteristics and subject to critically high temperatures as flight speed increases, much current engineering emphasizes components and structures. The design of hypersonic inlet diffusers, for example, presents a distinct challenge. As an example of thinking in this area, the sketch on page 46 shows a possible hypersonic diffuser featuring an all-external-compression isentropic spike, drag-free cylindrical cowl, throatbleed system, and no subsonic diffuser. This design, cited by Richard J. Weber in his paper "A Survey of Hypersonic-Ramjet Concepts" (ARS Preprint 875-59), gives a kinetic-energy efficiency above 90 per cent at hypersonic speeds. Keeping structural temperatures to acceptably low levels may pose the chief problem with hypersonic ramjets. Both regenerative cooling and radiative structures are under study to control steady-state temperature. However, recent advances in surface coatings (see George Gerard's discussion on page 49) will perhaps provide the immediate solution for putting ramjets in the hypersonic range.

Discussions of detailed engineering solutions to the now largely predictable performance of both conventional and unconventional ramjets, as described in articles in the April 1959 *Astronautics*, reside chiefly in the classified literature. The directions of thinking and work on ramjets for both supersonic and hypersonic ranges is reasonably clear, however, in papers presented at recent ARS meetings, as noted in the bibliography.

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Communications

(CONTINUED FROM PAGE 31)

all respects has improved the characteristics of the original vacuum-tube equipment.[3] For example, voltage-controlled oscillators previously had problems concerned with drift or temperature stability, linearity and repeatability, and hysteresis; the new transistorized components which are offered and utilized today have improved the linearity from 1 to 2 per cent down to 0.1 and 0.2 per cent. The temperature stability has also improved from 5 to 10 per cent over limited ranges to 1 to 3 per cent over ranges from −20 to 100 C.

Along with transistorization has come a closer examination of the characteristics of the telemetry systems. Over the past few years, examination of the various parameters and techniques utilized in telemetry systems have been helping to elevate the art from its "black magic" status to an engineering field. Effects of component characteristics on system performance, accuracy requirements, repeatability, etc. have now entered upon the scene and have been the subject of several projects and articles.[3-7]

Advances in the past two years in the area of pulse-code modulation have made possible for the first time the accurate measurement and transmission of data which will allow independent evaluation of inertial guidance systems. Pulse-code modulation,[8-9] although not a new technique, has only recently been developed to the point where its use has been considered. Although a system has been utilized for some months now in a track program at Holloman, the first true PCM missile system is still in its early stages of development. Some flights of small, parallel-channel, pulse-code data have been successfully completed, and commercial use in testing the DC-8 has been contemplated with pulse-code modulation techniques. The inherent advantage of the pulse-code modulation technique is the transmission of digital data, which would allow accuracies in the order of 0.1 per cent. The future will require development of transducers of similar

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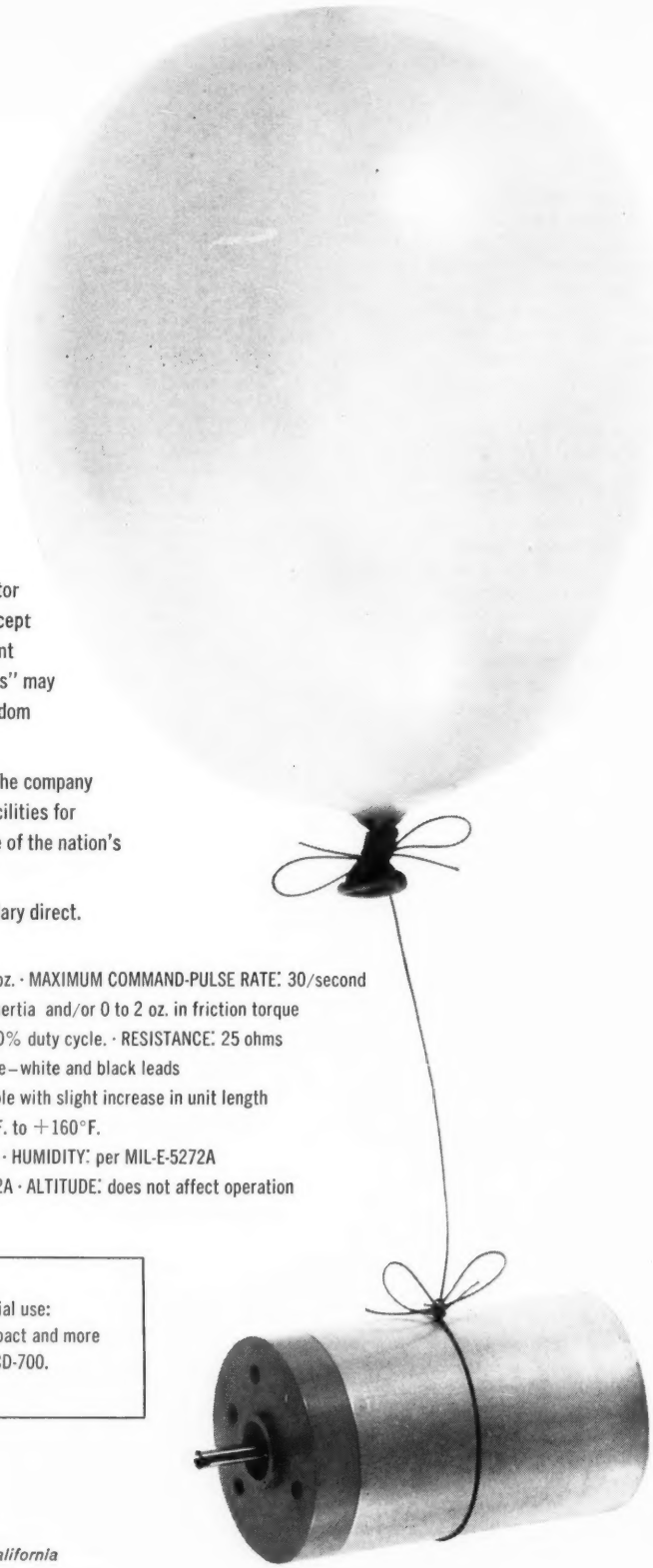

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DESIGN LIFE: 10^6 cycles each direction · TEMPERATURE: −65°F. to +160°F.
VIBRATION: 5 cps to 600 cps at 10 g or .020" double amplitude · HUMIDITY: per MIL-E-5272A
SALT SPRAY: per MIL-E-5272A · SAND AND DUST: per MIL-E-5272A · ALTITUDE: does not affect operation
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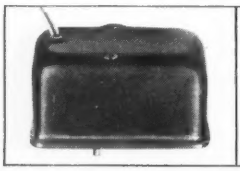

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accuracy in order to take full advantage of this system.

One of the greatest problems that has been plaguing missile-telemetry users has been the problem of obtaining an adequate number of high-frequency channels for measurement of such functions as vibration. Utilization of the old RDB, or now IRIG, standards limits the frequency-response capability of a particular system by the number of channels available to the system. The IRIG FM/FM system utilizes a percentage bandwidth related to the center frequency. Since the center frequencies vary from 400 cycles to 70 kc, the bandwidth of the individual bands vary from ±30 cycles at 400 cycles utilizing the ±7.5 per cent deviation to 10.5 kc for the 70 kc channel with a deviation of ±15 per cent. The modulation index of 5, which must be accepted with present-day equipment to preserve signal-to-noise ratio and limit the intermodulation products generated by a complex system, requires that data be limited to 2 kc on the high channel.

More Than One System Used

The problem arises when a vibration survey is required to measure the transmissibility of vibratory energy through a complex mechanical system such as an Atlas or Minuteman missile. In cases such as this, it is not uncommon to see a requirement for vibration measurement at 4 or 5 locations along the missile structure, which may total up to 15 measurements. Even if the frequency response is limited to 1 kc, the requirement far exceeds the capability of any single IRIG system. The solution in the past has been to utilize more than one system to obtain the suitable number of wideband channels.

Recently, application of an old technique in a new way has made possible a division of a standard IRIG system into a number of constant-frequency-bandwidth bands; the technique is known as Frequency Translation.[10] The transmission of six 1-kc response bands within one system is possible utilizing this technique. This has been accomplished by utilizing six identical subcarrier oscillators, the output of each oscillator being fed to a frequency translator, where it is heterodyned to a new frequency within the band but still retains its original bandwidth and its original data. The information is then frequency-multiplexed into a transmitter in the same manner as a standard FM/FM system, and transmitted to the ground. Reduction of the data requires either special filter units for the FM discriminator or retranslation of the transmitted subcarriers back to the normal frequency and then application to standard subcarrier discriminators.

An alternate technique analyzes the data before transmission and allows the information to be transmitted as low-frequency data.[11] This frequency-translation technique has many applications other than that mentioned. For example, it is possible, utilizing some of the standard telemetry transmitters available, to multiplex two 18-band IRIG systems onto one transmitter and transmit this information to the ground. This may be accomplished by translating one entire multiplex approximately 100 kc above the highest channel of the lower multiplex. Other techniques would allow special information to be translated and placed above a standard IRIG system or allow some number of channels to be duplicated from a frequency-response point of view and multiplexed with any number of other channels. The limitation of the frequency-translation technique for transmitted data systems is the bandwidth of the transmitter, the bandwidth capability of the receiver and that of the tape recorder. Among the recent developments that have made this system more attractive are the expansion of the bandwidth of several receivers and at least one transistorized tape recorder which now has the capability of extending the recorded bandwidth from the normal 100 kc out to 250 kc at the standard tape speed of 60 ips.

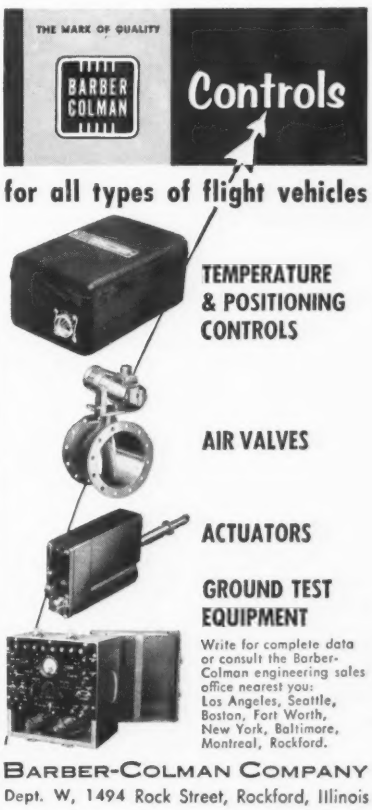
The transmission of information from satellites and spaceprobes has been a particular problem. Since in most cases the power capability of the payload is very small, new techniques have been required to allow long-range reception. Previous approaches have led to large, high-gain antennas, such as the 60-ft tracking parabolic dish which exists in several places in the world for tracking satellites, and the use of some radio telescopes such as Jodrell Bank, but this alone would not have been enough to handle the puny output of our initial satellites. The phase-lock-loop technique has increased the capability of receiving stations to track and receive data from the low-powered transmission of our satellites and spaceprobes.[12-14]

Utilization of the phase-lock-loop technique with the FM/FM telemetry system requires seriously limiting the number of subcarriers utilized, and the information bandwidth of each subcarrier must be restricted to a few cycles. The restrictions are a result of the characteristic high carrier power need for the phase-lock loop. For the receiver to track properly, approximately 80 per cent of the available transmitted energy must be retained in the carrier. This results in a low-modulation index with very little power available for distribution among the side bands. Effective data from such systems required the further application of phase-lock principle to the FM data discriminator.[16-17]

Transistorized Unit Available

Very few phase-lock-loop discriminators, however, have been available. The most recent addition is a miniature, transistorized phase-lock-loop discriminator, shown on page 31, which is now available as a standard commercial item. The new unit, aside from the reduction in size, weight, and power consumption, offers improved operation in every respect over the existing vacuum-tube L-C or pulse-averaging discriminators previously available.

The initial satellites did not present as much of a problem as that presented by some space vehicles today. Apogee of satellites, in most cases, has not exceeded 1000 miles, but moon shots concern themselves with distances of up to 240,000 miles. Receivers utilizing phase-lock-loop techniques have sensitivities of approximately −140 dbm.[2] Transmission to some of the inner planets, such as Mars and Venus, however, introduces dis-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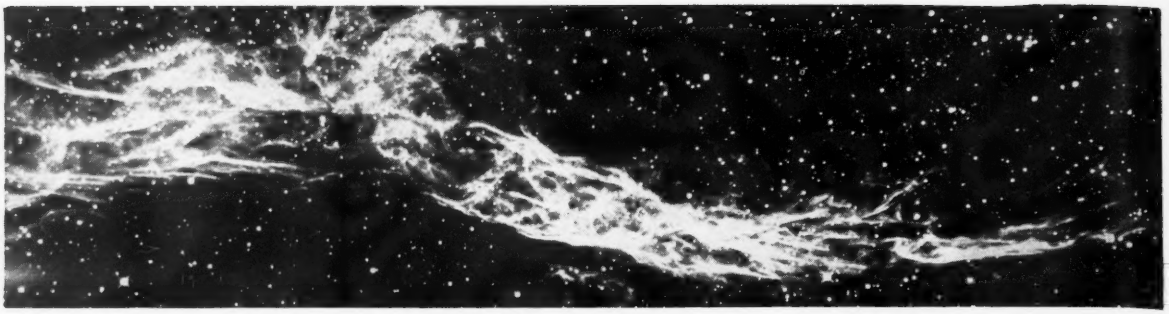

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tances in the tens of millions of miles. The free-space attenuation encountered under such conditions appears drastic, and more than phase-lock-loop techniques are required if any significant amount of information is to be transmitted from such trips.[15]

In addition to the distance and free-space-attenuation problem, there are several other problems that require attention. Galactic background radiation fields, which are generally predominant in the 250 to 1000 mc range; atmospheric-oxygen and water-vapor losses, which become predominant in the 3-kilomegacycle range; and celestial sources of discreet radiation, such as the sun, moon, planets, and radio stars—all fairly well defined—are of significant intensity to require constant attention.

New techniques are being involved for the efficient transmission of information over extremely long range. Redundant coding techniques will allow reconstruction of received data even when a large percentage is lost due to drop-out. Also, the application of microwave amplification by simulated electronic radiation (masers) and parametric amplifiers[18-19] increases the range ability for low-powered transmission by minimizing the system noise figure. The maser operates on the principle that a decrease in the energy level of a paramagnetic material will cause emission at a frequency which is determined by Planck's constant and the difference in the energy level. The parametric amplifier consists of a nonlinear reactance which will couple energy from a pump source to the signal frequency. Both types of amplifiers are regenerative and potentially unstable. Gains in the order of 20 to 30 db are obtainable from either, with a noise figure of 1 db or less. A third device, which is somewhat along the same lines, is the tunnel diode.[20] Future applications will probably utilize tunnel-diode along with maser and parametric amplifiers.

Range Must Be Increased

The requirement for radar systems has also been seriously affected by the new long-range missiles and space work. In fact, it is now necessary to increase the range of radar systems by orders of magnitude in order to provide early-warning techniques for nose-cone re-entry and to perform tracking services for satellites and space vehicles. Some of the same techniques previously mentioned are being employed in this field. In the case of groundbased equipment, high transmission powers can be employed to increase the range coverage and to provide a radar-detection capability in high-density countermeasures environment. Versatility is required for multimode operation to include height finding, multitarget tracking, missile guidance, and high-capacity detection. In general, the higher frequencies have been found most suitable for airborne radar.

Consideration is being given to the use of millimeter-wavelength radars for communication in space travel. Several important problems exist in this area. One of the main reasons for adapting millimeter-wavelength propagation is due to the existing congestion of the lower frequency spectrum.

The general trend in radar design is development of multipurpose systems which perform all the radar functions, including self-contained radar programing in data processing. The required flexibility and automaticity would be provided by electronically controlled beam scanning. Power density levels for radar transmitters in the order of 20-megawatt peaks and antenna gains in the order of 45 db are becoming commonplace.

The magnetron, which was the main transmitter tube of 10 years ago, is replaced in modern radar sets by a master oscillator power amplifier chain consisting of wideband traveling-wave driver tubes and high-powered klystron output stages. In some instances, the required power levels are obtained by paralleling output amplifiers. Antenna beamwidths are now of the order of a fraction of a degree, and pulse-code techniques are being utilized to achieve resolution measurable in feet.[21] In addition, modern radars operate coherently rather than noncoherently to obtain the fourth dimension of target-velocity resolution.

The preservation of phase and amplitude intelligence for a pulse-coded coherent radar system requires transmitter stabilities in the order of one part in 109, which may be satisfied by crystal-controlled master oscillator systems. The increased data which is accumulated requires increased data-handling capability, which is obtained by the utilization of high-speed digital data processing techniques. Storage tubes are utilized to optimize the writing and retention rates of visual displays, and television-type scan conversion for radar permits optimum data presentation.

To retain a reasonable volume with the increased complexity, the employment of subminiaturization and microminiaturization techniques has been adopted for even this type of ground equipment, along with solid-state devices, such as transistors and diodes. The necessary reliability for satisfactory system performance is assured by the application of unit redundancy, automatic fault detection, and unit switchover on most modern devices.

Future trends in the communication field will see the use of electronic scanning which will allow construction of large, stationary high-gain antennas for long-range search and data acquisition with highly accurate tracking. Future systems will possibly contain hundreds of phase-coherent solid-state transmitters built in as a part of an array of radar antennas, each putting out a few watts in the millimeter-wavelength region. This type of radar can be used in spacecraft for detection and communication.

Power Problems Difficult

As previously discussed, the power problems for space work can become difficult to handle. One of the solutions mentioned was increased gain for ground receiving antennas. For earth installation, the antenna can be limited to a size consistent with the mechanical problem of pointing the antenna at a specific area in space. The speed at which this unit must be directed at a space vehicle may be more demanding on the mechanical design than any other feature. These considerations will influence future designs in the direction of electronic

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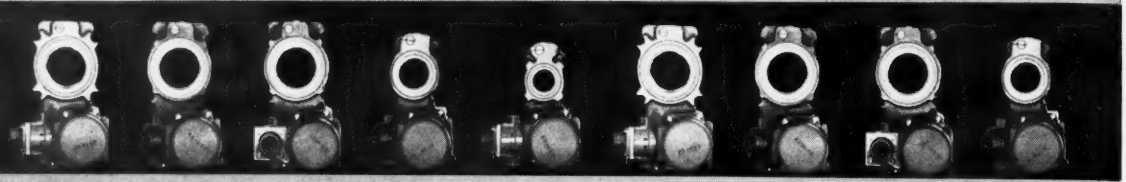

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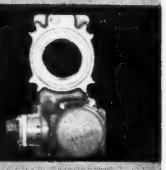

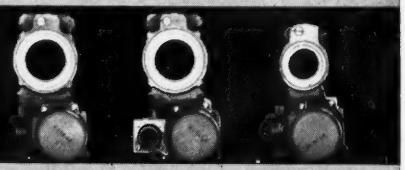

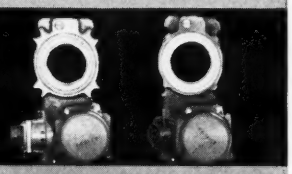

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scanning systems, where the beam is positioned electronically rather than the mechanical antenna rotated physically.

The minimization of system noise figure will be the outstanding problem of space communication, since this will reduce the minimum detectable signal. Noise figure is defined as the ratio of the noise output of the actual amplifier to that of a noiseless amplifier with the same gain. Thermal noise (KTB) is the usual limiting factor in ground receivers, where "K" represents Bolzman constant, "T" the equivalent temperature in degrees Kelvin, and "B" the noise bandwith of the amplifier in cycles per second. "K" remains constant; assuming "B" remains constant, the variable becomes "T." The thermal problem applies to the antenna and the input amplifier. On vehicles, the antenna temperature will be relatively low, and thus low-noise amplifiers—maser and parametric—will be utilized to their greatest capacity.

Can Detect Smaller Signal

The reduction of the noise figure means that a smaller signal may be detected by the system. The consequence will be that an extended range will be obtained in space for a given system with the identical power output within our atmosphere. A typical figure for the improvement factor is 10 to 1 in space over earth of the signal-to-noise ratio, or approximately a 300 per cent increase in range. These techniques, of course, are applicable to any communication system.

One of the conclusions that can be drawn from this is that the future communication requirements of space vehicles would call for a communication satellite fairly close to earth. This communication satellite would in effect be a retransmission point for signals transmitted from outer space.

The gain from parametric amplifiers and low antenna temperature does not apply in the whole to groundbased receiving stations. The significant increase may be obtained by utilizing parametric amplifiers, but the antenna temperature would remain rather high due to the ambient temperature on earth. Therefore, the incorporation of a retransmission station above the earth would make possible reception from long-range space probes transmitting at low power output. The communication satellite would in turn retransmit the signals to the earth's station.

In general, a communication satellite would have to be "fixed" rather than the type which is presently spinning around the earth. The equipment required would probably derive its energy from a combination of battery packs and solar batteries. The development of equipment for such satellites would be required in the near future, and hopefully will be ready before shots at Mars or Venus.

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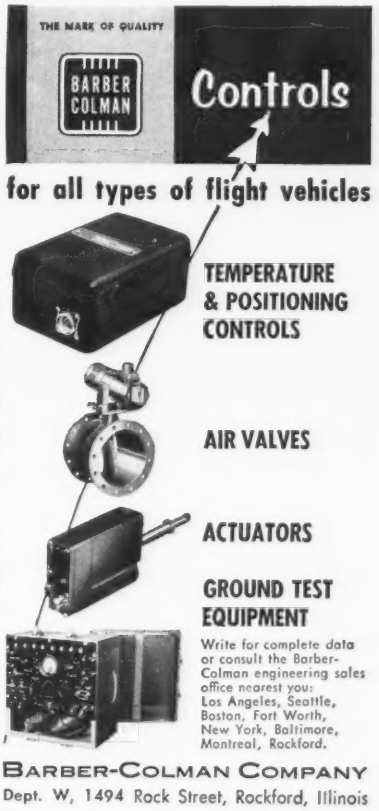
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Mechanical Force Amplifier: Amplifier output can be used to position automatic controls, recording pens, encoders, small valves, switches, or hydraulic servo systems. Input forces can be less than 0.04 oz; output is precisely positioned with forces up to 18 oz. Linear position is identical motion. Useful travel is 2 in.; full-scale travel time varies from 1 to 20 sec. American Meter Co., P.O. Box 309, Garland, Tex.

Scintillation Counting System: Ultra-fast electronics give sensitive C^{14} and H^3 counts with speed and precision. A light-tight sample holder permits dark preadaptation, sample precooling, and versatility of sample shape and material. Use of a freezer is optional. Baird-Atomic, Inc., 33 University Rd., Cambridge 38, Mass.

Time-Delay Relay: Two new miniature transistorized relays for missiles and satellites feature nominal delay times from 0.1 to 3 min over an ambient temperature range of −55 to 150 F. Operating voltage range 18–30 v dc; max wt, 0.35 lb; minimum operating cycles, 50,000. Leach Corp. Relay Div., Los Angeles, Calif.

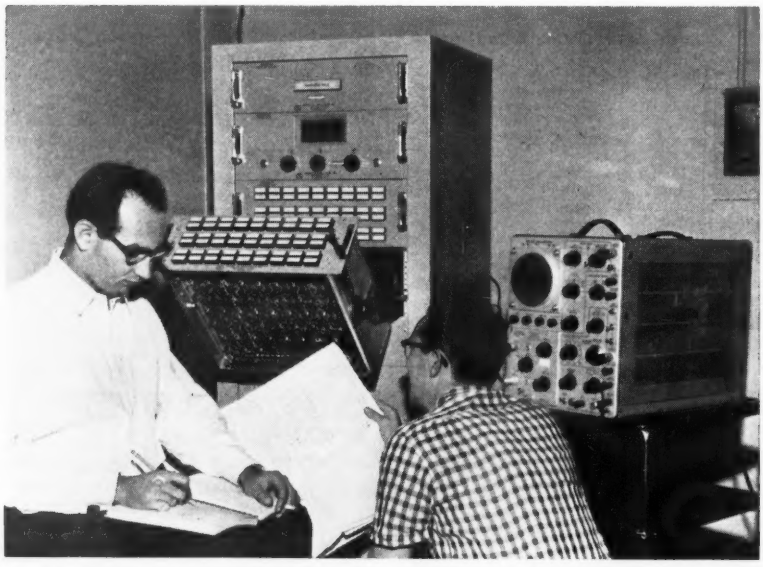
Bench-Type Bearing Washer: Model MC-4-1 ball and roller-bearing washer cleans antifriction bearings from the smallest to 5 in. in diam. The unit

utilizes the cleaning action of both solvent and air under pressure. Complete cleaning requires no removal of seals or shields. Average time required for each bearing is less than a minute. Bearing Inspection, Inc., 3311 E. Gage Ave., Huntington Park, Calif.

Gas and Vapor Detector: On-the-spot determinations of the concentrations of toxic gases and vapors may be made with the Unico Model 400 gas detector. Gas concentration is read from the calibration curve or color standards on the tube box. Thirty-six tubes available. Union Industrial Equipment Corp., 40 Beech St., Port Chester, N.Y.

Extruded Niobium Tubing: Rod and tube extrusions made from niobium (NB; also known as columbium) are available for rocket and missile components and atomic powerplants. Wolverine Tube Div., Calumet & Hecla, Inc., 17200 Southfield Rd., Allen Park, Mich.

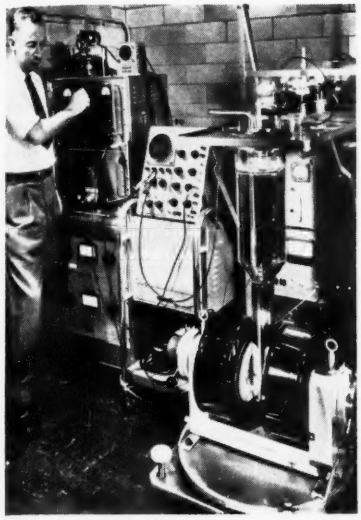
Parametric Amplifier Diodes: Noise temperatures as low as 50 deg above absolute zero for a diode cooled by liquid nitrogen, and only 100 deg above absolute zero for a diode at room temperature, have been obtained in a high gain 3000 mc parametric amplifier. The diode comes in two hermetically-sealed versions—one for below mc and a second for the microwave region. Hughes Aircraft Co., Semiconductor Div., Hawthorne, Calif.



Static Sequencer With Applications

Developed to control auxiliary equipment in the countdown of the Polaris missile, the pictured static sequencer can trigger 60 checkout operations per minute. It has no moving parts, is self-timing, compares information received, and verifies accuracy of test results. It can be adapted for equipment testing, data handling, and machinery automation. Magnetic Amplifiers Inc., El Segundo, Calif.

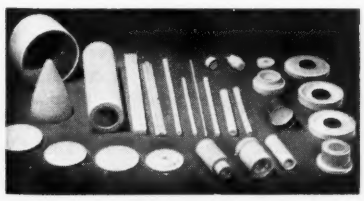
Packaged Maser On the Way



Cryostats like this Collins, produced by Arthur D. Little, Inc., cool maser crystal with liquid helium. Electromagnets (at base of cryostat) and other equipment generate and measure field on maser.

Research at Sylvania Electric Products aims at reducing the bulk of the laboratory maser amplifier to rugged, compact form for military and more widespread general use in long-range radar, tracking, space communications, and radio astronomy. Although contributing to research (see May 1959 *Astronautics*, page 50), maser developments are still in the laboratory stage. The Sylvania concept of a packaged maser system includes an integral cryostat and a small permanent magnet, replacing the huge electromagnets used in laboratory systems. Small mobile masers would make it possible and practical to boost the range of conventional radar by a factor of $2^1/_2$ to 7.

Beryllium Oxide Applications: Berlox, an electrical insulator with thermal conductivity equal to that of brass, is



available in fabricated fired-to-shape, and extruded shapes withstanding temperatures up to 400 F. National Beryllia Corp., 4501 Dell Ave., N. Bergen, N. J.

Pressure-To-Frequency System: Model PFS-2 system combines in a single package a reactance-controlled subcarrier oscillator and a single-coil variable-resistance pressure transducer. This FM system, over a wide range of temperatures, measures absolute, gauge, or differential pressures. The unit will operate at a large number of IRIG bands, as well as at subcarrier frequencies well above the highest present IRIG band. Ultradyne Inc., P.O. Box 3308, Albuquerque, N.M.

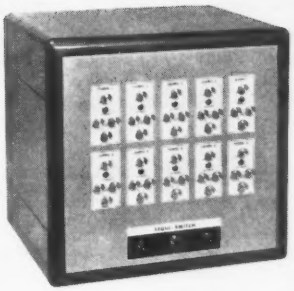
Servo System Control: The "hunting" problem in servo systems used in fire control, analog computers, test equipment, and high-accuracy indicating devices has been eliminated by an infinite-resolution device called the Spiralpot. It features a single length of resistance wire which is continuously contacted by the wiper. The brush assembly prevents grooving tendency and rapid linear shifting. The unit will withstand 15 g shock in any axis. G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena 1, Calif.

Coaxial Line Terminations: Improvements in line terminations permit proper function of the units within temperature limits of −450 to 440 F. Resistive elements of these units are made of platinum films fired on ceramic forms and treated with silicone varnish. The elements do not become superconductors at temperatures as low as 4.2 K. Stoddard Aircraft Radio Co., Inc., 6644 Santa Monica Blvd., Hollywood 38, Calif.

Power Transistors: A newly developed line of NPN power transistors makes it possible to eliminate input and output transformers. The units provide miniaturization, improved response, and ease of applying negative feedback. They feature collector voltages up to 80 v, a maximum cutoff frequency of 150 kc, and meet MIL-19500A specifications. Four types are available for resistive loads, and three types for inductive loads. CBS-Hytron, Danvers, Mass.

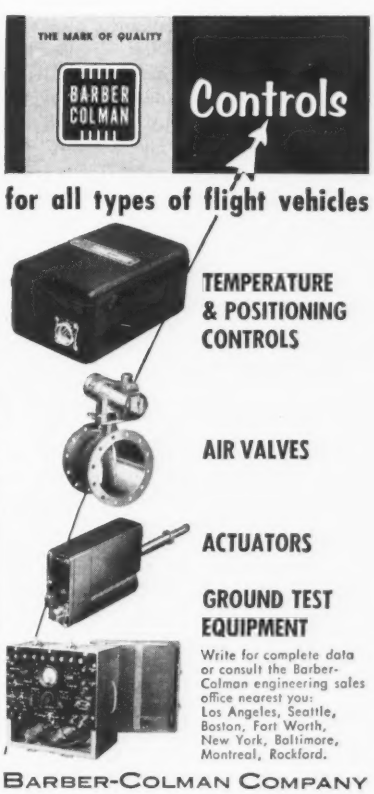
Coils for Electronic Equipment: A line of foilwound wafer coils is particularly suitable for use with traveling wave tubes, klystron electromagnets, maser devices, and beamed deflection magnets. The wafer construction enables the coils to be assembled in multiples so air, water, or gas cooling can be used. Tube appendages and RF connectors can pass directly through the windings of the coil. Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N.Y.

Electronic Switching: For use in



scanning transducers, a device known as the Segui-Switch has many applications such as telemetering, dynamic force and pressure studies, and multipoint data gathering. It can be used with an oscilloscope to give simultaneous readings that can be photographed for analysis. Through bridge inputs, any combination of transducers may be read out. Control Devices, Inc., 925 S. Eton, Birmingham, Mich.

Polyether Foam Process: A "one-shot" method of producing polyether foam—a versatile cushioning, padding, and insulation material—eliminates many intermediate production steps. The method also permits adding all components at the mixing head. Greater uniformity in cell structure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Astrodynamics

(CONTINUED FROM PAGE 30)

determined with a higher degree of precision from the artificial satellites (O'Keefe–1958; Lecar, Sorenson, and Eckels–1959; Kozai–1959a), and a later determination has revealed the exciting possibility of a third harmonic, implying a north-south asymmetry (pear-shapedness) of the earth, as well as a fourth harmonic determined observationally and not purely from theory as heretofore (O'Keefe, Eckels, and Squires–1959; King-Hele –1959).

Role of Atmosphere

For low-altitude satellites, the constants associated with the atmosphere are often more influential in determining a satellite's orbital behavior than are the gravitational ones. Such effects have stimulated Jacchia's recent analysis (1959) of the variations in the atmospheric density profile due to solar-terrestrial disturbances. After several interim atmospheres were developed by Siry–1958a; Schilling and Sterne–1959; Harris and Jastrow–1959; Whitney–1959; King-Hele–1959, and others, the 1956 ARDC model atmosphere has been revised into a 1959 model by Pond (1959). For a recent survey of the drag coefficient, see Baker (1959a).

The solar parallax, expressed in radians, is the ratio of the earth's equatorial radius to the astronomical unit. Since the equatorial radius is known in laboratory units (meter, foot, etc.) with a relative uncertainty that is smaller than that of the solar parallax, the latter is the critical link in the ratio of the astronomical unit to laboratory units. Whatever the discordance of opinion over the relative merits of astronomical and laboratory units of distance, there is unanimity of desire for knowledge of the ratio between them. Thus the solar parallax, which has long been a matter of intellectual interest to the astronomer, now emerges as a matter of absorbing practical interest to the astronaut. Since all distances in the solar system are relatively well known in astronomical units, the determination of any one of them in laboratory units will yield the desired ratio and the solar parallax.

Accordingly, the radar measurements of the distance of Venus by Price, Green, et al. (1959) were of exceptional interest. Their data have been restudied by Herrick, Westrom, and Makemson (1959), who derive $8''.80185 \pm 0''.00005$ for the solar parallax, the uncertainty being an order of magnitude better than the best astronomical determination, which is $8''.7984 \pm 0''.0004$ (Rabe–1950). Plans for new measures on Venus and minor planets may well establish the new value on a firm footing, but it should be accepted for the present only as very tentative. Meanwhile Lilley and Brouwer (1959) are undertaking a radial velocity determination of the solar parallax, using radio-Doppler measures of the 21-cm hydrogen line. The proposed method looks very promising, and may exceed the accuracy of Rabe's value by an order of magnitude.

Radar Ranging

Radar echoes from the moon are being measured with increasing accuracy (Yaplee, Bruton, Craig, and Roman–1958) and promise in time to give us a value for the moon's distance that is better than the dynamical one. Since the latter value is determined from a geocentric gravitational constant based on the equatorial value of the acceleration of gravity and the equatorial radius, a possible radar distance will improve the geocentric constant and probably also the equatorial radius, which is currently a bit less accurate than equatorial gravity.

The theory of the librations of passive satellites, related to the tidal stabilization of satellite platforms, has been further developed by Robinson–1958; Klemperer–1959; and Baker–1959b. The effects of solar and lunar perturbations of close-earth satellites have been expanded upon by Kozai–1959b, and shown to predict for certain satellites an earlier end than that which would be caused by drag alone. The effects of air drag on satellite orbits have been considered in specialized areas (e.g., Rowell and Smith–1959; Vinti–1959a).

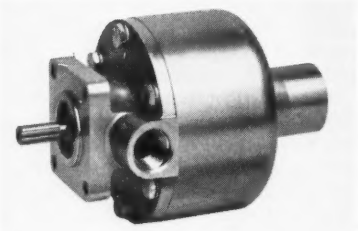
In the area of precision orbit calculation, there have been such matters as the comparison of Cowell's method, Encke's method, and the method of variation of parameters in the integration of lunar trajectories (Baker, Westrom, et al.–1959) and studies of differential expressions for low-eccentricity orbits (Herrick, Walters, and Hilton–1959).

It has been found that the orbits of the American satellites could be determined with precision by means of Minitrack observations. Accuracies of one milliradian of arc have been achieved. This figure refers to the residuals of the observations relative to orbital arcs several days in length. Since the mean distances of the satellites are of the order of 1000 miles, this means that satellite positions are determined with a mean accuracy of the order of a mile (Siry–1958b).

Interactions between satellite rotational motions and the earth's magnetic field have also been studied. The observed magnetic damping of the rotational period of Vanguard I, 1958 β_2, is in conformity with that to be expected as a result of the calculated value of the earth's magnetic field in the neighborhood of the orbit of this satellite (Wilson–1959).

The search for analytical solutions to problems more complex than two-body ones has again been concentrated in the realm of satellites of an oblate earth (Vinti–1959b; Brenner, Latta, and Weisfeld–1959). Claims for what is accomplished in such studies must be carefully evaluated in the light of astronomical experience with real problems to which such solutions are only approximations, however elegant and rigorous they may be mathematically. The effects of thrust

Fuel Pump Series For Jet Engines



A new series of fixed-displacement, vane-type fuel pumps for jet engines has been announced by Vickers Inc. Div. of Sperry Rand, Detroit 32, Mich. The new pumps are said to provide weight savings of 10 to 25 per cent while meeting Military Spec Nos. MIL-E-5009B and 8595-B for contamination tolerance, and are designed for 1000 hr of service life.

Fuel-flow rates at pressures up to 1500 psi range from 400 to 50,000 lb/hr at up to 6000 rpm pump speed. Some models are capable of speeds up to 20,000 rpm and operation at pressures exceeding 1500 psi. All pumping parts are contained in a replacement cartridge providing design flexibility and simplified maintenance. The cartridge can be incorporated in a fuel-control body or other member to save space and weight. Otherwise, the housing is built around the cartridge to meet space limitations.

and drag, and of the attractions of sun and moon, and of the portions of the attractions of the bulge or of gravitational anomalies that are not included in the rigorous solution can only be treated as perturbations on it. Accordingly, the rigorous solution can only be regarded as a somewhat more complex reference orbit than the two-body one, to serve as a point of departure for a perturbation treatment on an Encke, variation-of-parameters, or other pattern.

The question posed is, then, a straightforward one: Do the simplifications in the perturbation terms outweigh the complications in the reference orbit? Probably a series of experiments will in the end give us the answer.

Educational Aspects

Astrodynamics has progressed on the educational side in the past year. More university courses are being offered, and the curricula offered at UCLA and the Univ. of Cincinnati have been supplemented by short courses at Yale and UCLA. The former tended to cover advanced areas of celestial mechanics, while the latter, a comprehensive course in the fundamentals, had a threefold increase in enrollment over its first presentation in 1958.

The challenge of payload will continue to emphasize precision techniques, with every ounce of fuel saved contributing to the success of a space venture, whether it be a spot-landing to supply a lunar depot or expedition, a reconnoiter of Mars or Venus, or an interception or rescue mission close above the earth's surface. Nongravitational and relativistic accelerations are to be explored. Reference orbits and perturbation expansions and techniques offer a wide spectrum for experimentation and analysis. The relative roles of the "6-dimensional fix" (position and velocity) and of the differential correction in the adjustment of orbits must be further assessed for particular problems.

The geodetic satellite will offer the highest challenge to precision orbits and observation theory, and may then give us a foothold for the more accurate determination of the basic geocentric gravitational constant or coefficient of the zero-order harmonic in the earth's potential, so essential to the lunar spot-landing.

The Russian space-rocket endeavors, whose spectacular achievement in landing a lunar rocket within a target-distance only twice the present theoretical limit of accuracy, was the high point of 1959 astrodynamics. Russian space work will continue to challenge the western world. And whatever challenges are met or problems cleared away will open new vistas to the enterprising astrodynamicist.

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Hydraulic Peak Pressure Gauge

A new hydraulic pressure gauge which indicates peak pressures with full-scale ranges of 0–4000 and 0–10,000 psi has been developed by Hydel, Inc., 223 Crescent St., Waltham 54, Mass., for use in troubleshooting hydraulic systems subjected to excessive transient pressures.

The instrument contains in one package a pressure pickup, an amplifier, and a peak detector, followed by a large meter, which indicates the true absolute peak of pressure transients as short as 1 millisec in duration. In operation, the meter deflects rapidly to indicate the value of a peak and then decays slowly to the steady-state pressure. An output terminal for attachment to an oscilloscope or oscillograph is provided for those instances where a visual or permanent record is desired.

(CONTINUED FROM PAGE 108)

the House Committee on Science and Astronautics demanded that Mallan offer proof of his assertion that Lunik was "the biggest hoax in history." In his testimony Mallan contended that evidence indicated the Goldstone signals were radio waves reflected off the planet Jupiter, since "on certain frequencies the characteristics of Jupiter's signals match the characteristics of the signals received at Goldstone."

Mr. Mallan even doubts the reality of Sputniks I, II, and III, for he says that "Up to now, no such data (raw scientific data available for study by scientists of the Free World) has ever been released by the Russians in any field of rocket or space research. All that the Kremlin has released have been boasts and lies based on the apparent success of three sputniks." If Mr. Mallan had just a little faith in the ability of American scientists to evaluate data published in technical journals by their Soviet counterparts, he would learn that the sputniks are not only real but have furnished a substantial amount of useful information to the scientific community.

He would also learn that data from Lunik on cosmic rays and terrestrial corpuscular radiation, published in the April 11, 1959, issue of *Doklady Akademii Nauk SSSR*, are in essential agreement with data from Pioneer IV, the American space probe that was launched March 3, 1959. His credulity would no doubt be strained by the knowledge that the report was received by the editors of *Doklady* on Feb. 25, 1959—six days *before* Pioneer IV was launched.

The author "explains in detail" why he knows Soviet long-range missiles are a Big Red Lie. They do not exist "because they don't have the guidance." They don't have the guidance because he saw no evidence of miniaturization anywhere in the Soviet Union. Hence, "without ultramodern miniaturized electronic computers . . . an intercontinental missile is a brainless beast. The Russians do not have miniaturized computers. They do not think at all in terms of miniaturization. To them, reliability in electronic devices means BIG devices powered by BIG batteries or generator and BIG vacuum tubes." Ergo, the Soviet ICBM is a hoax.

Mallan debunks Soviet air power almost as loudly, but not so vehemently or at the same great length, as he does Lunik and Soviet guided missiles.

In the last part of the book, the author treads on political and philosophical ground. He asks the question "How does Communism manage to hoodwink the whole world and win such frightened respect?" "The answer," says Mallan, "is simpler than the solution to the problem. The Russian Communists have, from the beginning, carried on an offensive along four vital fronts. These are: The Strength Offensive, currently being pursued by the technique known as 'sputnik diplomacy'; The Peace Offensive; The Science Offensive; The Culture Offensive.

"These offensives, all in the field of propaganda, are subtly interwoven. They reverberate through the Free World as well as through the world of Communism. They have built a mighty myth that is difficult to recognize and even tougher to expose. The majority of individuals of all nations on earth have accepted it. I was among them—before I visited the Soviet Union."

Mr. Mallan is aware of only one phase of the Big Red Lie. The examples he cites are but a few terms in an infinite series of distortions. Lies, like sins in general, are of two kinds—those of commission and those of omission. It is the latter kind of lie that he did not perceive, and that has led him to make faulty deductions. The realities of Communism include not only the use of the lie to befuddle the Free World, but also the use of American knowhow to solve the key technological and industrial problems of the Communist World. Since Communism's avowed purpose is to dominate the world, it is a serious error to underestimate the current technological upsurge in the Soviet Union. Branding certain Soviet achievements as hoaxes on the basis of superficial and incomplete evidence, and thus creating a feeling of false security in the West, is in itself a contribution to the Big Red Lie.

—F. J. Krieger
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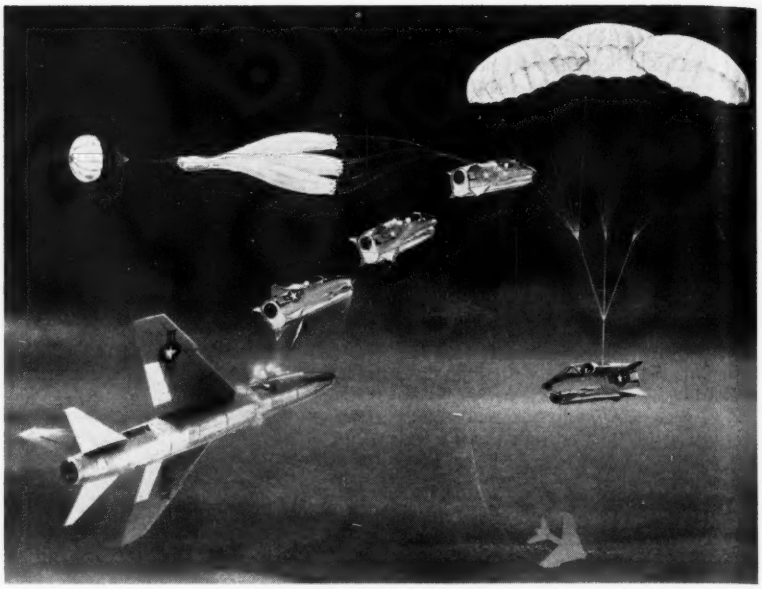

Chance-Vought to Build Aircraft "Space Capsule"

Artist's conception of emergency escape feature of integrated flight capsule to be developd for the Navy by Chance Vought. Similar to a space capsule, it would provide environmental protection for pilot, freeing him of pressure suit, oxygen mask, chute, and other personal gear. Sequence shows capsule separating from Vought F8U Crusader aircraft, being propelled by short-duration rocket, extending guidance fins and speed brakes, and descending on parachute cluster.

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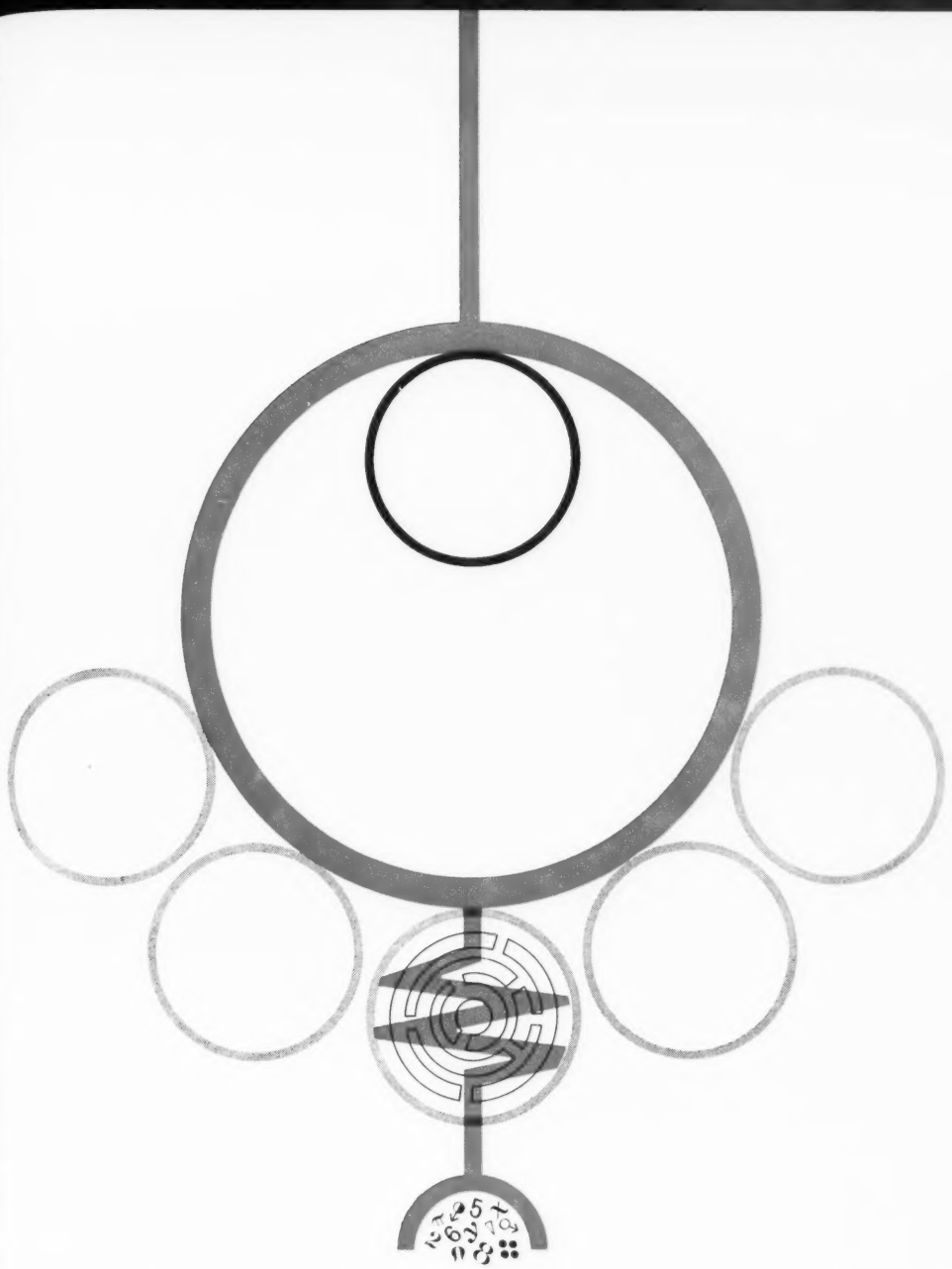

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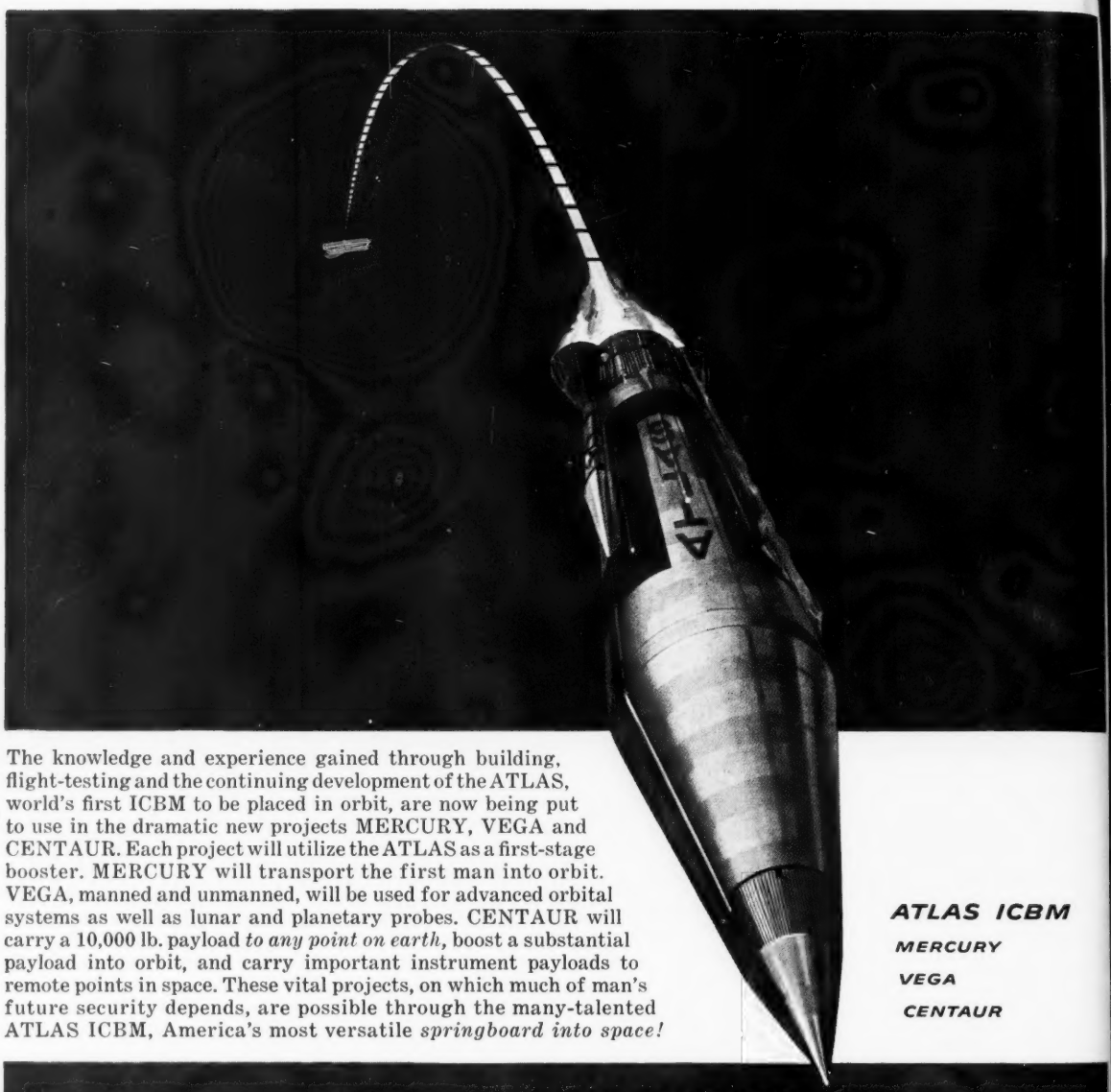

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